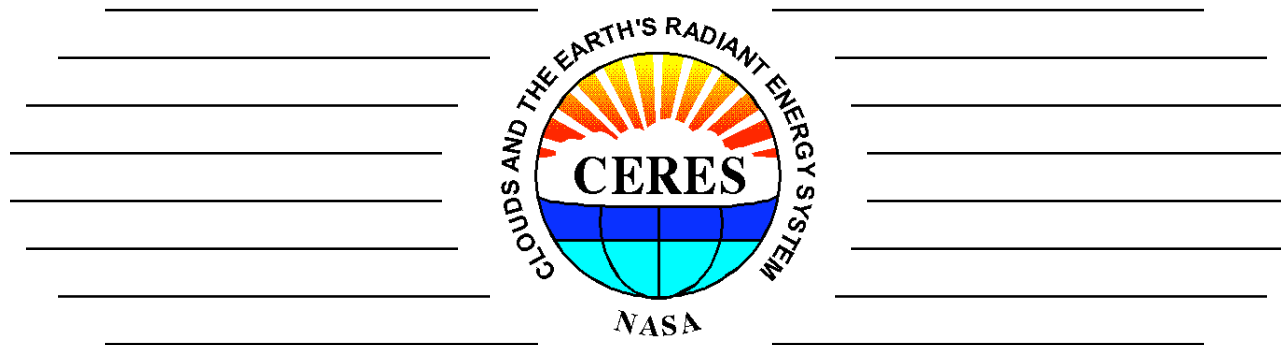


# Terra/Aqua Instrument and ERBE-Like Calibration Status Report



**Kory J. Priestley**  
**Susan Thomas, Denise Cooper**  
**Phil Hess, Grant Matthews, Peter Szewczyk,**  
**Dale Walikainen, Robert Wilson**

**CERES Science Team Meeting**

Hampton, VA  
November 1-3, 2005



NASA Langley Research Center

**Atmospheric**  
SCIENCES

# Agenda

---

## **CERES Project Status**

**Engineering/Housekeeping Status**

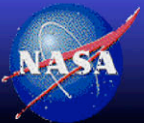
**FM-4 SW Channel Anomaly - Aqua Spacecraft**

## **Cal/Val Report**

**Edition2\_Rev1 Review**

**Preparations for Edition3 BDS & ERBE-like**

**- Spectral Darkening of CERES SW channels**



**NASA Langley Research Center / Science Directorate**



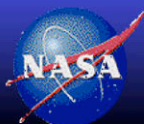
# CERES Terra/Aqua Health & Status

**With the exception of the SW channel on the CERES/Aqua FM-4 Instrument, the CERES Terra/Aqua instruments are functioning nominally...**

**All temperatures and voltages remain within limits**

**No discernable or alarming trends.**

| Spacecraft | Instruments | Launch | Science Initiation | Collected Data (Months) |
|------------|-------------|--------|--------------------|-------------------------|
| TRMM       | PFM         | 11/97  | 1/98               | 9                       |
| Terra      | FM1, FM2    | 12/99  | 3/00               | 68 +                    |
| Aqua       | FM3, FM4    | 5/02   | 6/02               | 41 +                    |
| ?          | FM5         | ?      | ?                  | ?                       |



**NASA Langley Research Center / Science Directorate**



# CERES/Aqua FM-4 SW Anomaly History & Status

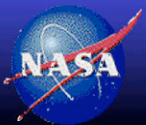
---

## History-

- On March 30, 2005 at 18:42 GMT the CERES/Aqua FM-4 instrument stopped collecting valid Shortwave channel radiometric measurements.
- Anomaly was characterized by an immediate railing 'high' of the SW channel data stream, which subsequently drove the SW channel bridge balance electronics into a reset condition in an attempt to bring the SW channel output on-scale.
- The Total and Atmospheric Window radiometric channels continued to function nominally.

## Current Status-

- All attempts to recover the SW channel measurements have been unsuccessful.
- Modeling has indicated the problem is most likely the result of a failed resistor (possibly a detector) in the SW channel Bridge Balance Circuitry.
- Preparing for upcoming Calipso launch.



NASA Langley Research Center / Science Directorate





# CERES/Aqua FM-4 SW Anomaly Science Impacts

---

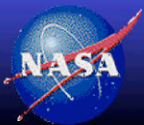
## Near Term

No impact assuming the CERES/Aqua FM-3 instrument is collecting cross-track data.

## Long Term

If anomaly cannot be resolved, longer term science issues include (in order of priority)

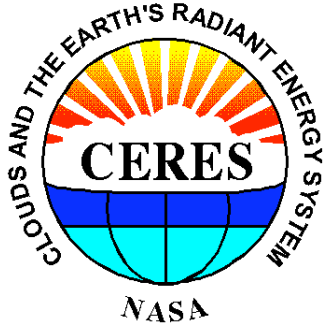
- significantly increased risk of a gap from Terra/Aqua climate record to the beginning of NPOESS using FM-5 in 2011/2012.
- the second Aqua CERES instrument for the A-train was to scan along-track for multi-angle views over the lidar/radar track to examine effects like 3-D radiative transfer
- the second Aqua CERES instrument is also used to perform intercalibrations with GERB: but these can be accomplished by the second Terra CERES as long as two CERES instruments are active on Terra
- the second Aqua CERES instrument is also used during cloud/aerosol field experiments to provide multi-angle data that tracks a pre-selected surface site (e.g. ARM site).



NASA Langley Research Center / Science Directorate



# Radiometric Performance Summary

|       |  |       |
|-------|--|-------|
| _____ |  | _____ |
| _____ |  | _____ |
| _____ |  | _____ |
| _____ |  | _____ |
| _____ |  | _____ |
| _____ |  | _____ |
| _____ |  | _____ |



NASA Langley Research Center

**Atmospheric**  
SCIENCES

# Operational Coverage Request

**INSTRUMENT WORKING GROUP**  
CLOUDS AND THE EARTH'S RADIANT ENERGY SYSTEM

[Introduction](#) [Activities](#) [Documentation](#) [Operations](#) [Production](#) [Data](#) [Personnel](#)

**OPERATIONS**

Daily Statistics: [PFM](#) [FM1](#) [FM2](#) [FM3](#) [FM4](#)

Mode Command Logs: [PFM](#) [FM1](#) [FM2](#) [FM3](#) [FM4](#)

Daily Mission Modes: [TRMM](#) [Terra](#) [Aqua](#)

Instrument Operations: [TRMM](#) [Terra](#) [Aqua](#)

HK Trend Plots:  
[Terra](#) [Terra \(Edit\)](#)  
[Aqua](#) [Aqua \(Edit\)](#)

[Spacecraft Events](#)

[Instrument Coverage Request](#)

[SITE INDEX](#)

**Langley Research Center**

© NASA Langley Research Center  
Last Updated: Fri Aug 27 2004 16:29:11  
Web Curator: Phil Hess ([p.c.hess@larc.nasa.gov](mailto:p.c.hess@larc.nasa.gov))  
NASA Responsible Official: Kory Priestley ([k.j.priestley@larc.nasa.gov](mailto:k.j.priestley@larc.nasa.gov))  
[NASA Privacy Statement](#) [Feedback on Langley Products and Services](#)



<http://asd-www.larc.nasa.gov/Instrument/operations.html>



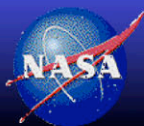
NASA Langley Research Center / Science Directorate



# CERES BDS and ERBE-Like Product Status

| Spacecraft | Product   | Version  | Available | Months Processed   |
|------------|-----------|----------|-----------|--------------------|
| TRMM       | BDS       | Edition1 | Yes       | 1/98 - 8/98 , 3/00 |
|            | ERBE-Like | Edition1 | Yes       | 1/98 - 8/98 , 3/00 |
|            |           | Edition2 | Yes       | 1/98 - 8/98 , 3/00 |
| Terra      | BDS       | Edition1 | Yes       | 2/00 - present     |
|            |           | Edition2 | Yes       | 2/00 - 6/05        |
|            | ERBE-like | Edition1 | Yes       | 2/00 - present     |
|            |           | Edition2 | Yes       | 2/00 - 6/05        |
| Aqua       | BDS       | Edition1 | Yes       | 6/02 - present     |
|            |           | Edition2 | Yes       | 6/02 - 3/05        |
|            | ERBE-like | Edition1 | Yes       | 6/02 - present     |
|            |           | Edition2 | Yes       | 6/02 - 3/05        |

Note: **Red** text indicates months are in final validation prior to public release.



NASA Langley Research Center / Science Directorate



# BDS and ERBE-Like Release Strategy

---

**Edition1 - Static Algorithms and coefficients - baseline product used in cal/val protocol**

**Edition2 - Utilizes temporally varying coefficients to correct for traceable radiometric drift. All spectral changes are broadband and 'gray'.**

**Edition3 - Release date Fall 2006. Will incorporate temporally varying spectral artifacts in the SW measurements. A complete re-analysis of Ground Calibration with additional component characterization measurements.**

**Revisions - Advance capabilities to the users prior to the release of the next Edition.**

**Edition2 products lag Edition1 by a minimum of 4 months, revisions may lag Edition releases.**



NASA Langley Research Center / Science Directorate



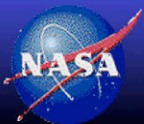
# Instrument Artifact Removal Strategy

Remote sensing instruments generally exhibit time varying artifacts in their data products. For CERES these artifacts stem from either of 2 physical entities.....

- Radiometric Gain Change
  - Wavelength independent change in sensor responsivity
  - Corrections implemented in Count Conversion algorithm (SS1)
- Spectral Response Change
  - Wavelength dependent change in sensor optics
  - Corrections implemented in Spectral Unfiltering algorithms (SS2)

The Edition2 production strategy assumes that spectral response changes are 'Gray' over broad spectral regions. In other words, we assume uniform spectral response changes in these broad regions.

| Radiometric Channel | Spectral Region |         |
|---------------------|-----------------|---------|
|                     | SW              | LW      |
| Total               | <3.0 um         | >3.0 um |
| SW                  | <5.0 um         | -       |
| WN                  | -               | 8-12 um |



# Notification of Revision



## **CERES BDS (BiDirectional Scan) Terra Edition2 Data Quality Summary**

Investigation: **CERES**

Data Product: **BiDirectional Scan [BDS]**

Data Set: **Terra (Instruments: FM1, FM2)**

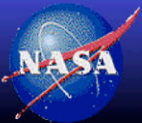
Data Set Version: **Edition2**

The purpose of this document is to inform users of the accuracy of this data product as determined by the CERES Team. This document briefly summarizes key validation results, provides cautions where users might easily misinterpret the data, provides links to further information about the data product, algorithms, and accuracy, gives information about planned data improvements. This document also automates registration in order to keep users informed of new validation results, cautions, or improved data sets as they become available.

This document is a high-level summary and represents the minimum information needed by scientific users of this data product. It is strongly suggested that authors, researchers, and reviewers of research papers re-check this document for the latest status before publication of any scientific papers using this data product.

### **Table of Contents**

- [Nature of the BDS Product](#)
- [Updates to Current Edition](#)
- [User Applied Revisions](#)** ←
- [Validation and Quality Assurance](#)
- [Current Estimated Uncertainty of Data](#)
- [Cautions When Using Data](#)
- [Expected Reprocesings](#)
- [References](#)
- [Web links to Relevant information](#)
- [Referencing Data in Journal Articles](#)
- [Giving Data to Other Users](#)



**NASA Langley Research Center / Science Directorate**

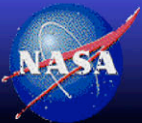


# BDS & ERBE-Like Edition2 Summary

•Cal/Val Protocol demonstrates radiometric stability of the Ed2 data products through 11/2004 of....

|         | Terra |      | Aqua |      |
|---------|-------|------|------|------|
|         | FM1   | FM2  | FM3  | FM4  |
| LWday   | .125  | .125 | <.1  | <.1  |
| LWnight | <.1   | <.1  | <.1  | <.1  |
| SW      | .2    | .3   | ~.1  | ~.1  |
| WN      | <.1   | <.1  | .125 | .125 |

Note: Values apply to all-sky global averages  
Units are in %/yr



NASA Langley Research Center / Science Directorate



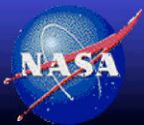


# BDS & ERBE-Like Edition2 Summary

•Cal/Val Protocol demonstrates radiometric stability of the Ed2 data products through 11/2004 of....

|         | Terra |      | Aqua |      |
|---------|-------|------|------|------|
|         | FM1   | FM2  | FM3  | FM4  |
| LWday   | .125  | .125 | <.1  | <.1  |
| LWnight | <.1   | <.1  | <.1  | <.1  |
| SW      | .2    | .3   | ~.1  | ~.1  |
| WN      | <.1   | <.1  | .125 | .125 |

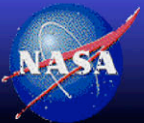
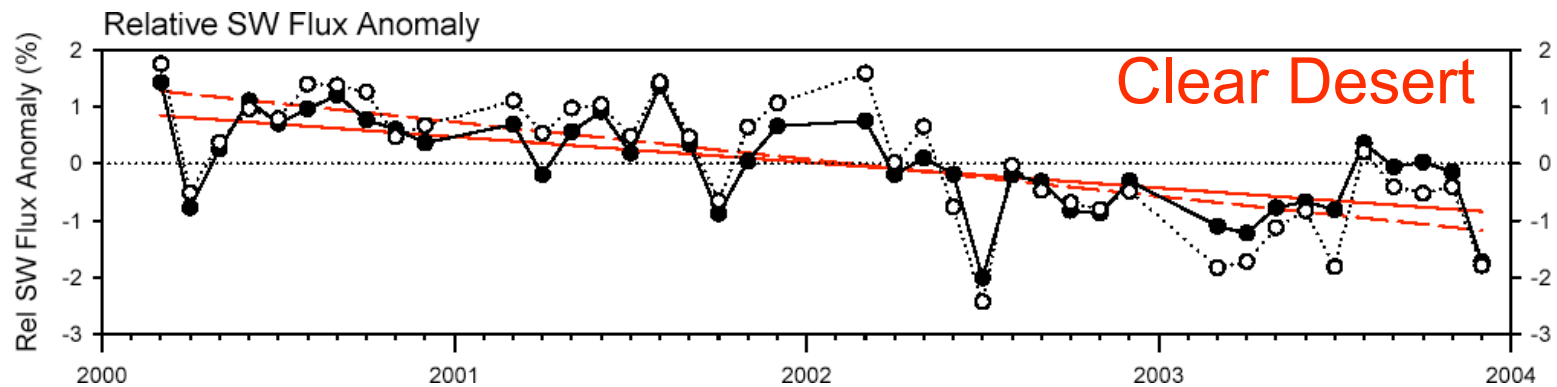
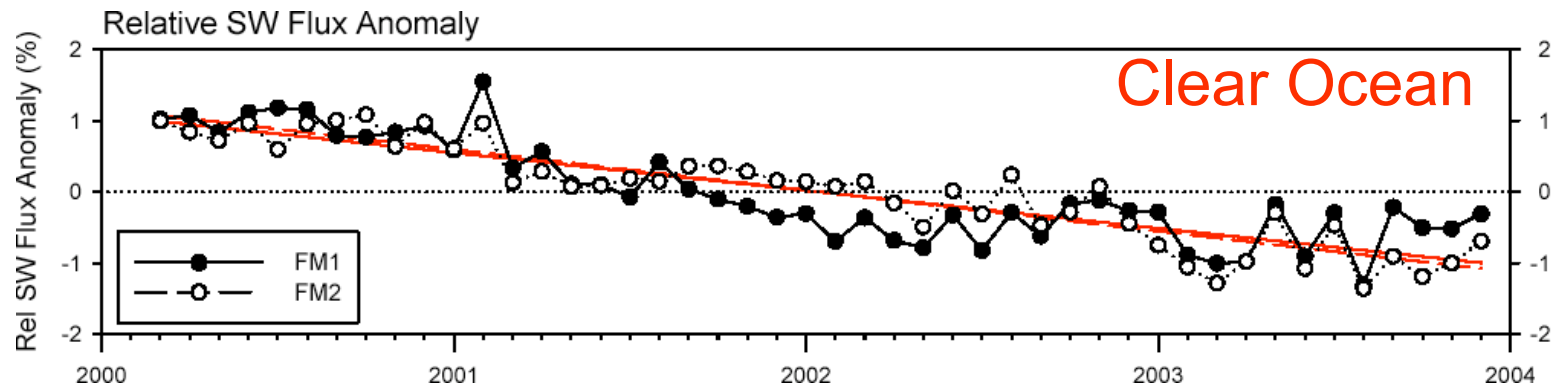
Note: Values apply to all-sky global averages  
Units are in %/yr



NASA Langley Research Center / Science Directorate



# CERES SSF Ed2B SW TOA Flux Anomaly



NASA Langley Research Center / Science Directorate



# **Direct Comparison of Nadir Radiance Measurements**

**Two CERES instruments on a common platform allows for a unique validation opportunity.....**

## **Direct Comparison of simultaneous Nadir measurements**

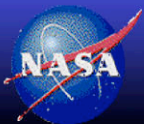
**Each CERES/Terra instrument views nadir every 3.3 seconds**

**Thus, we obtain nearly simultaneous measurements of the same geo-location ( $\Delta t < 3.3$  seconds)....**

**Spatial, angular, and temporal sampling issues are virtually eliminated.**

**26,000 co-located (but not independent) measurements in a given day, provides a very rigorous statistical tool.**

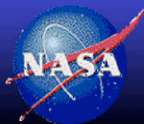
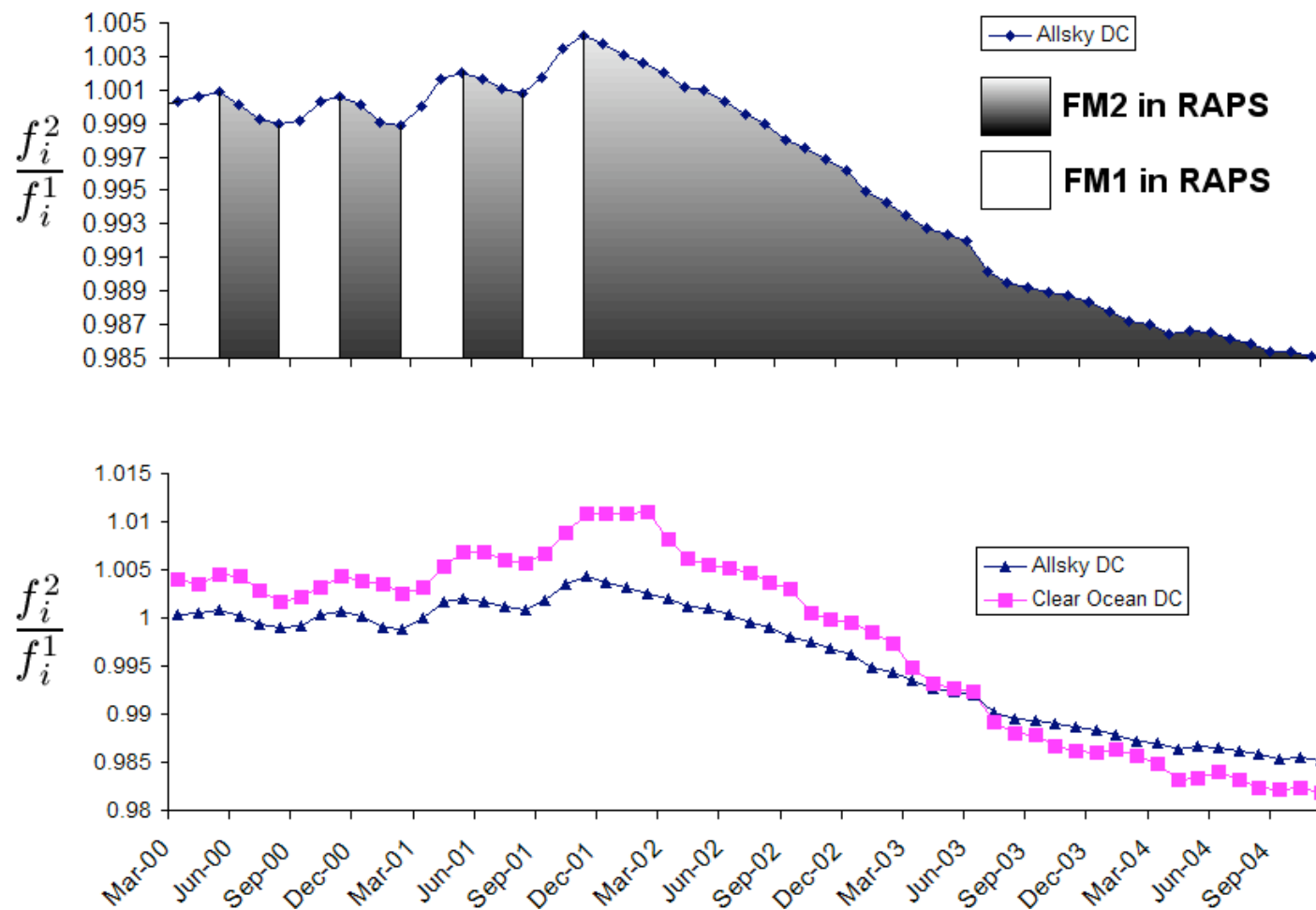
**Results can be discretized by scene type to enhance the analysis.**



**NASA Langley Research Center / Science Directorate**



# Edition2 BDS SW Nadir Direct Comparison

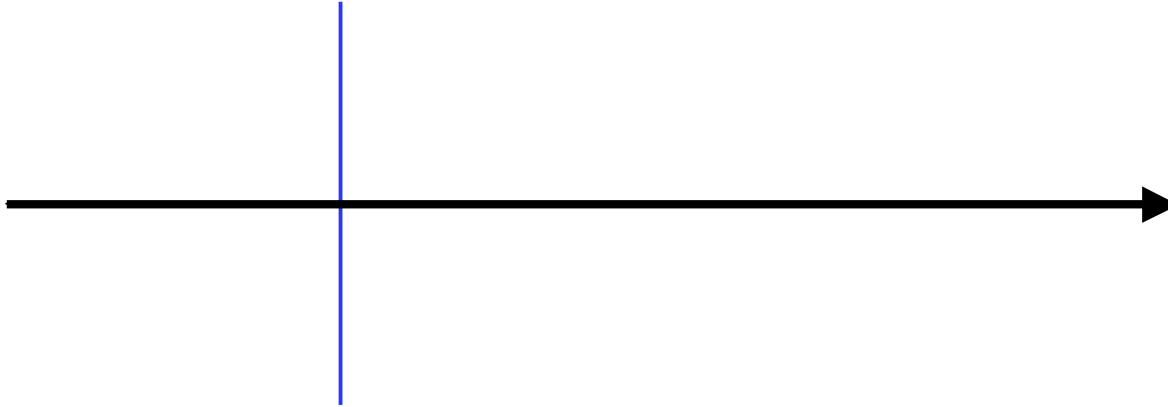


NASA Langley Research Center / Science Directorate

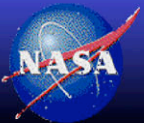
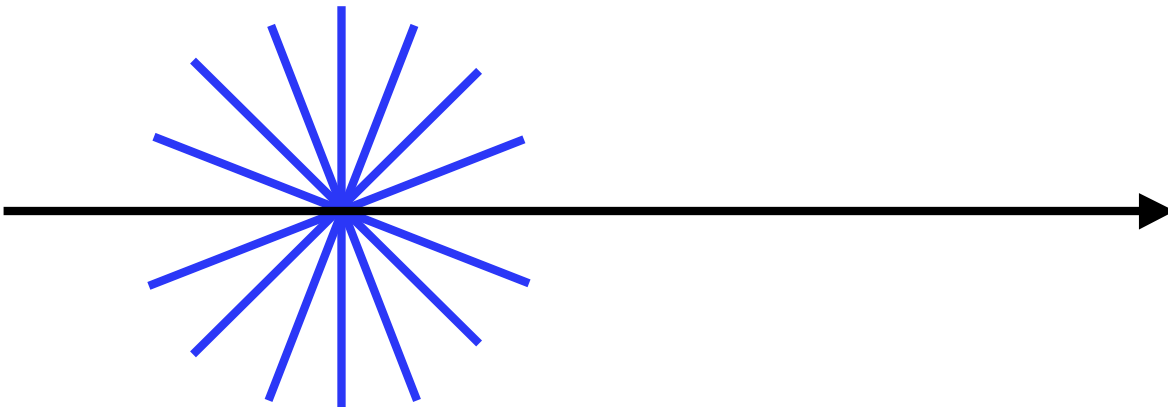


# Whats the difference between RAPS and FAPS?

**FAPS**



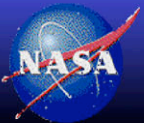
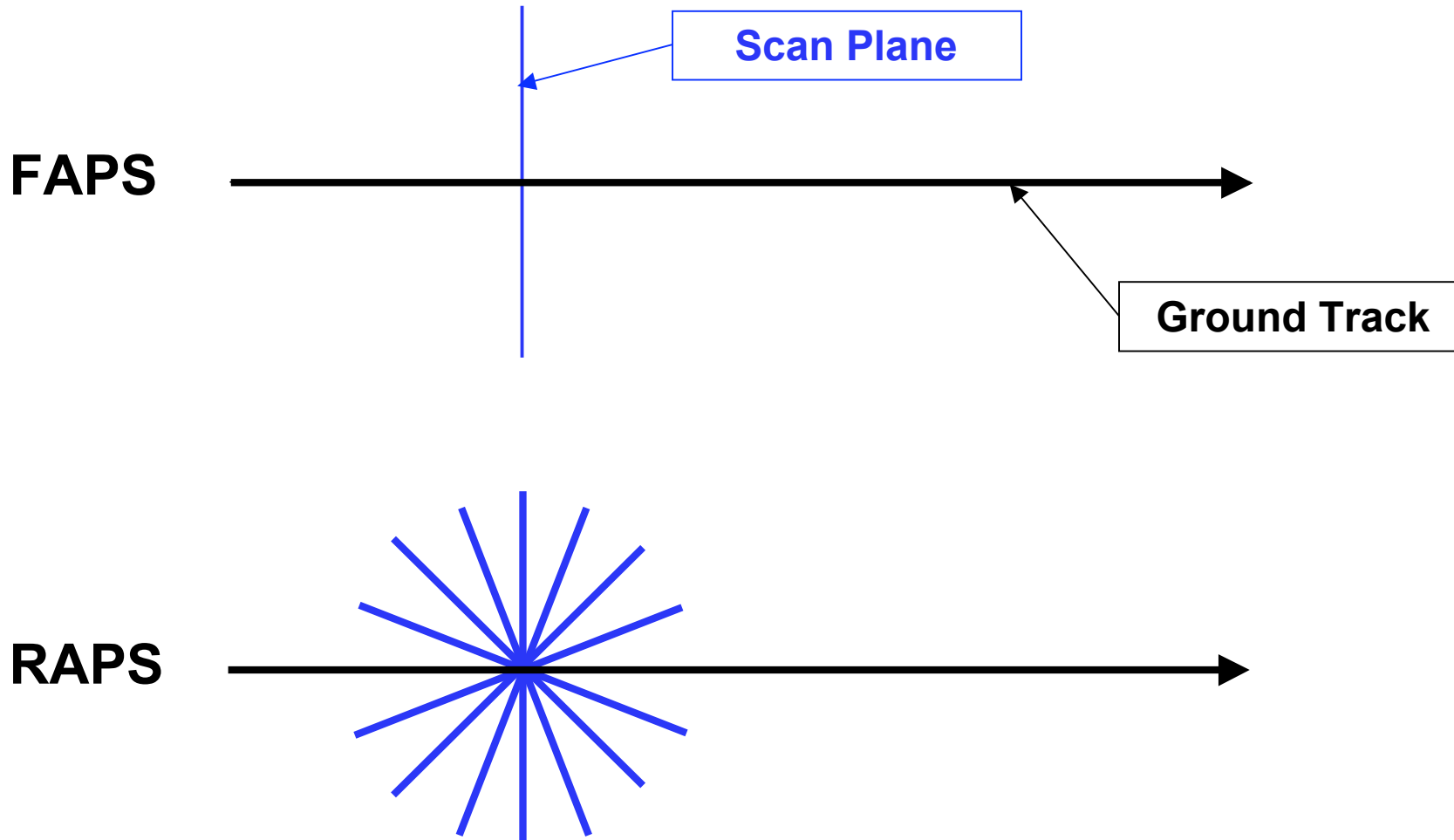
**RAPS**



NASA Langley Research Center / Science Directorate

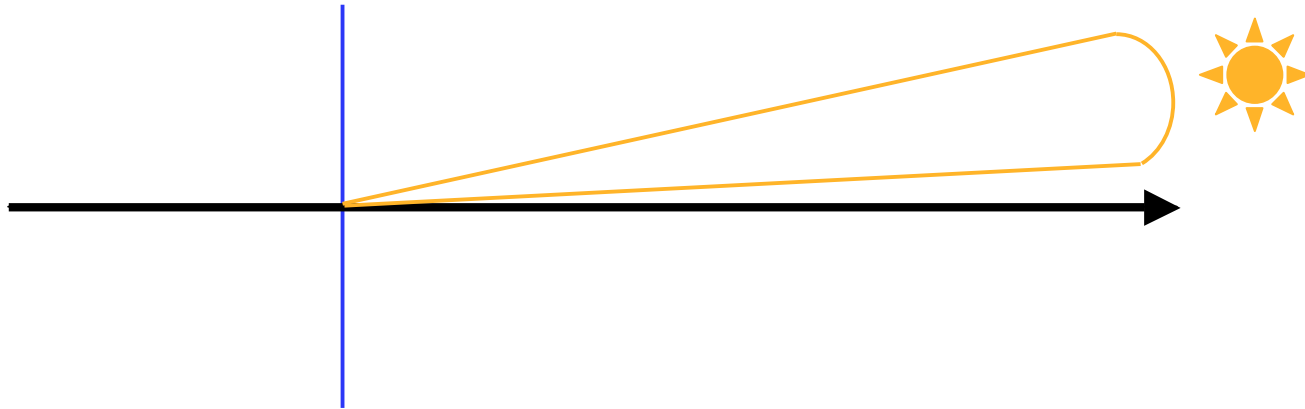


# Whats the difference between RAPS and FAPS?

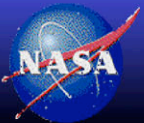
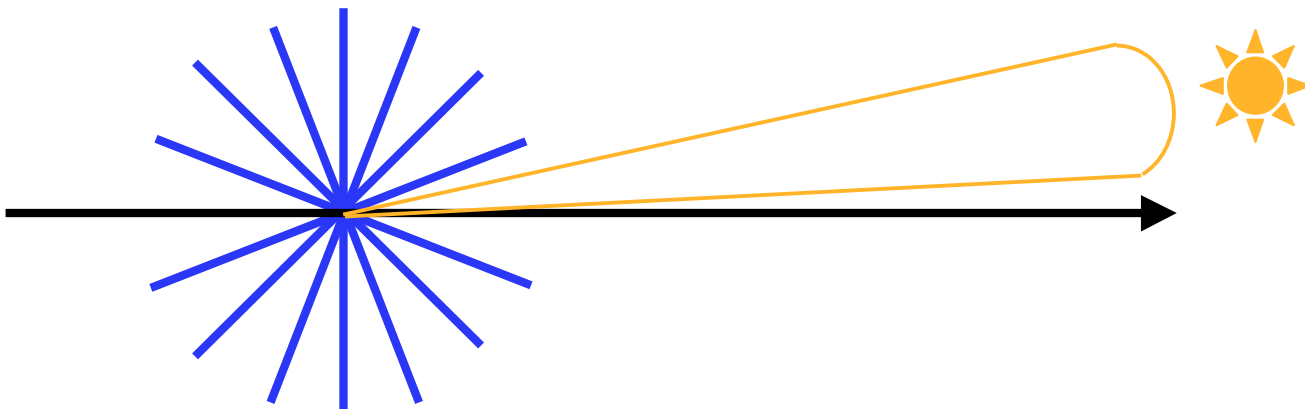


# Whats the difference between RAPS and FAPS?

**FAPS**



**RAPS**

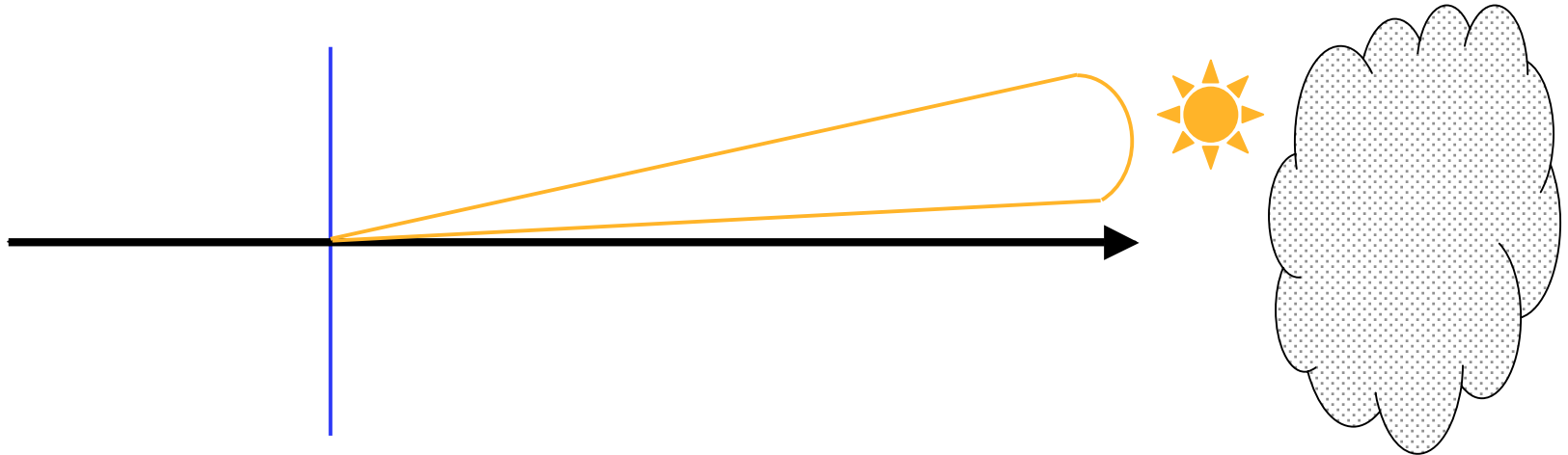


NASA Langley Research Center / Science Directorate

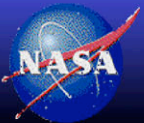
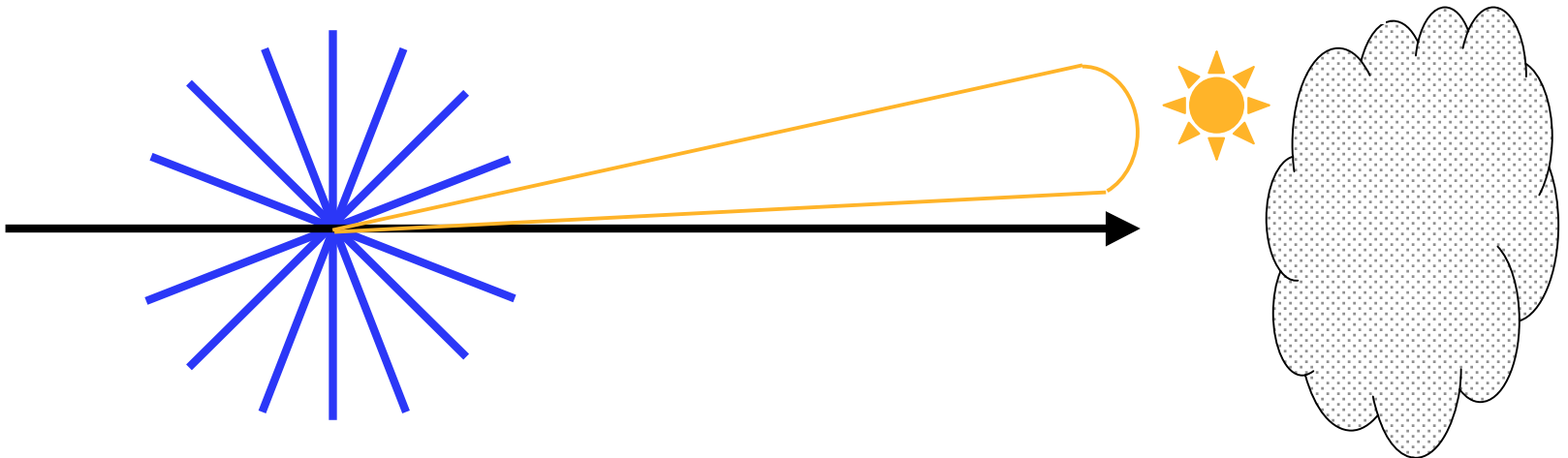


# Whats the difference between RAPS and FAPS?

**FAPS**



**RAPS**



NASA Langley Research Center / Science Directorate





# Operations to Characterize Spectral Darkening

| Month (2005) | FM1 Azimuth Gimbal | FM1 Solar Calibrations | FM2 Azimuth Gimbal | FM2 Solar Calibrations | FM2 Solar Exposure | FM2 RAM Direction     | Darkening Rate Impact |
|--------------|--------------------|------------------------|--------------------|------------------------|--------------------|-----------------------|-----------------------|
| February     | Xtrack             | Yes                    | Xtrack, Atrack     | Yes                    | Nominal            | Nominal (lunar scans) | Nominal               |
| March        | Xtrack             | Yes                    | Xtrack             | Yes (Daily)            | Accelerated        | Accelerated (solcal)  | No Change             |
| April        | Xtrack             | Yes                    | Rotating           | Yes                    | Reduced (note1)    | Nominal               | No Change             |
| May          | Xtrack             | Yes                    | Rotating, Atrack   | Yes                    | Eliminated (note2) | Reduced (note2)       |                       |
| June         | Xtrack (note3)     | Yes                    | Xtrack (note4)     | No                     | Eliminated         | Eliminated            |                       |
| July         | Xtrack (note3,5)   | Yes                    | Stowed             | No                     | -                  | -                     |                       |
| August       | Xtrack             | Yes                    | Stowed             | No                     | -                  | -                     |                       |
| September    | Xtrack             | Yes                    | Xtrack (note6)     | No                     | Eliminated         | Eliminated            |                       |
| October      | Xtrack             | No                     | Xtrack             | No                     | Eliminated         | Eliminated            |                       |
| November     | Xtrack             | No                     | Xtrack             | No                     | Eliminated         | Eliminated            |                       |

**Notes:**

1. Short-Earth scan profile turn-around reduced 8 degrees on March 31, 2005 to both FM1 and FM2.
2. Expanded solar-avoidance region criteria May 13, 2005.
3. Greenland Summer Solstice Terra-Aqua Inter-Calibration, June 6- July 6, 2005
4. GERB Operations, June 9-30, 2005.
5. Nighttime internal calibrations, July 1-7, 2005.
6. Valencia Over-Flights, September 12-17, 2005.

# Operations to Characterize Spectral Darkening

| Month (2005) | FM1 Azimuth Gimbal | FM1 Solar Calibrations | FM2 Azimuth Gimbal | FM2 Solar Calibrations | FM2 Solar Exposure | FM2 RAM Direction     | Darkening Rate Impact |
|--------------|--------------------|------------------------|--------------------|------------------------|--------------------|-----------------------|-----------------------|
| February     | Xtrack             | Yes                    | Xtrack, Atrack     | Yes                    | Nominal            | Nominal (lunar scans) | Nominal               |
| March        | Xtrack             | Yes                    | Xtrack             | Yes (Daily)            | Accelerated        | Accelerated (solcal)  | No Change             |
| April        | Xtrack             | Yes                    | Rotating           | Yes                    | Reduced (note1)    | Nominal               | No Change             |
| May          | Xtrack             | Yes                    | Rotating, Atrack   | Yes                    | Eliminated (note2) | Reduced (note2)       |                       |
| June         | Xtrack (note3)     | Yes                    | Xtrack (note4)     | No                     | Eliminated         | Eliminated            |                       |
| July         | Xtrack (note3,5)   | Yes                    | Stowed             | No                     | -                  | -                     |                       |
| August       | Xtrack             | Yes                    | Stowed             | No                     | -                  | -                     |                       |
| September    | Xtrack             | Yes                    | Xtrack (note6)     | No                     | Eliminated         | Eliminated            |                       |
| October      | Xtrack             | No                     | Xtrack             | No                     | Eliminated         | Eliminated            |                       |
| November     | Xtrack             | No                     | Xtrack             | No                     | Eliminated         | Eliminated            |                       |

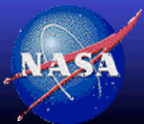
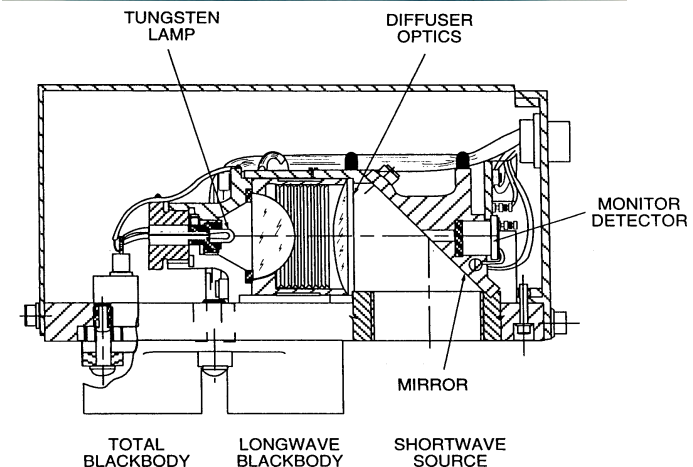
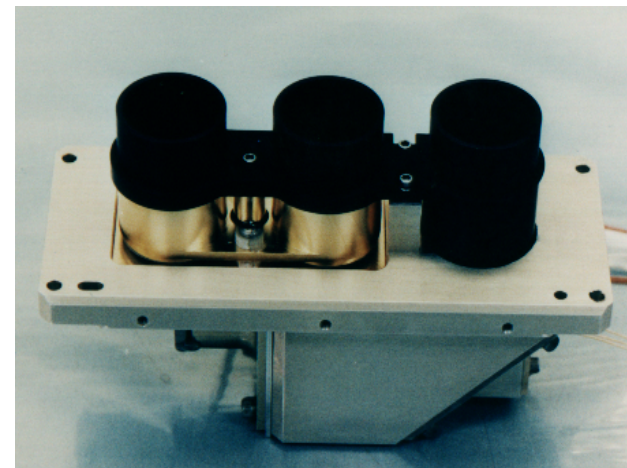
## Notes:

1. Short-Earth scan profile turn-around reduced 8 degrees on March 31, 2005 to both FM1 and FM2.
2. Expanded solar-avoidance region criteria May 13, 2005.
3. Greenland Summer Solstice Terra-Aqua Inter-Calibration, June 6- July 6, 2005
4. GERB Operations, June 9-30, 2005.
5. Nighttime internal calibrations, July 1-7, 2005.
6. Valencia Over-Flights, September 12-17, 2005.

# CERES Onboard Calibration Sources

## Internal Calibration Module (ICM)

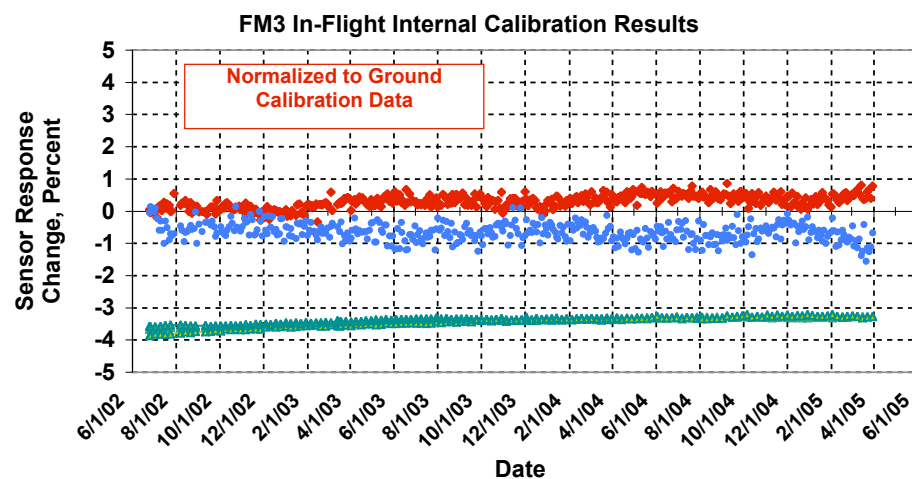
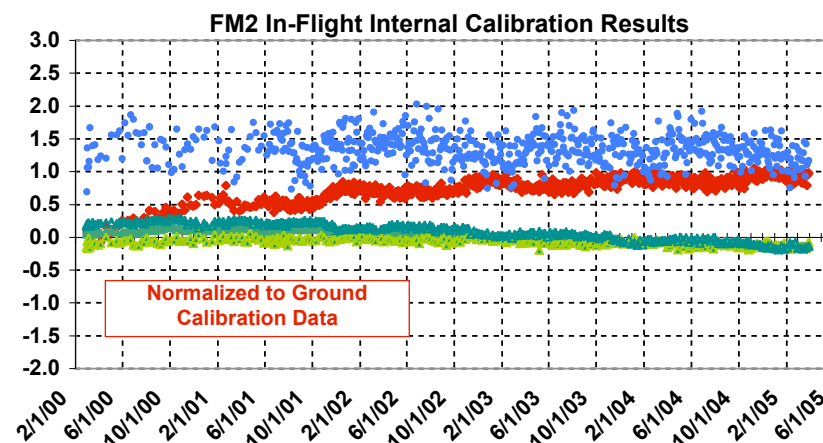
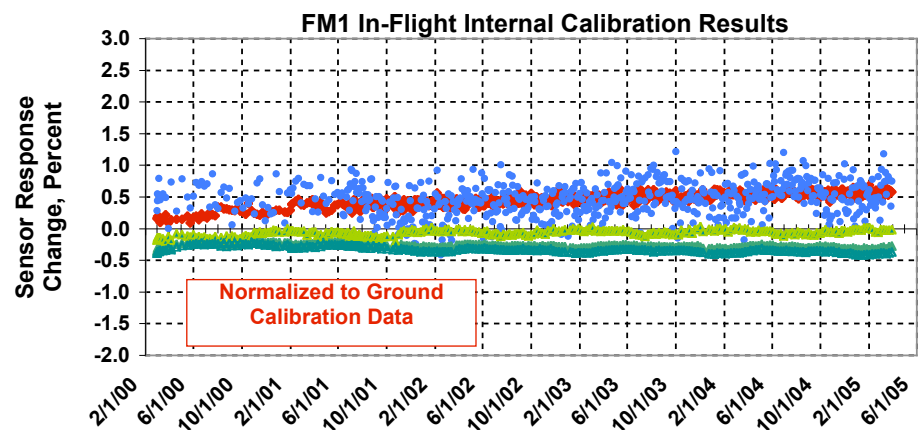
- ICM Provides 3 unique radiance levels for the SW and LW sources
- Blackbodies for the Total and Window channels
- Temperature knowledge obtained via Platinum Resistance Thermometers
- Quartz-halogen tungsten lamp for the Shortwave channel (2100, 1900, 1700 K spectrums)
- SiPd independently monitors lamp output
- Acceptance testing for lamps includes burn-in period of ~80 hours to screen for stability
- Narrow and broadband radiant intensity measurements are performed prior to acceptance
- Design specification is  $\pm 0.5\%$  stability over 5-year mission



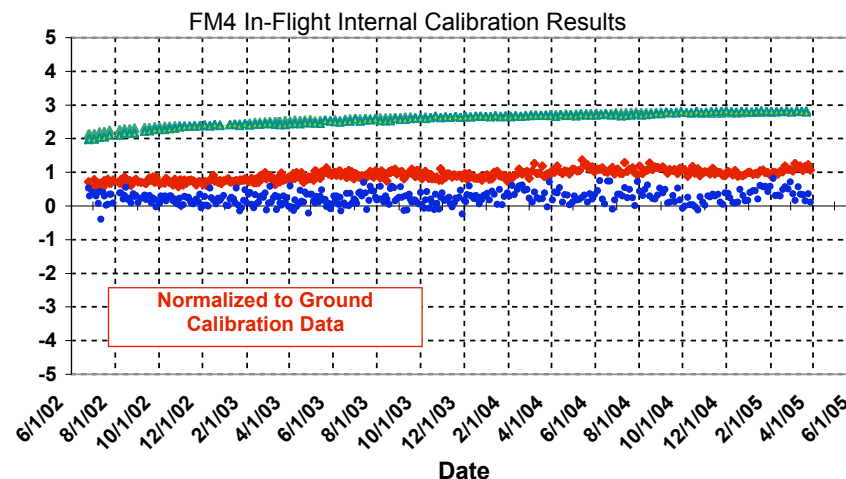
NASA Langley Research Center / Science Directorate



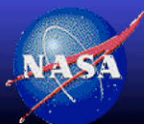
# CERES Internal Calibration Results



♦ TOTAL • WN ▲ SW-L2 ▲ SW-L1 ▲ SW-L3



♦ TOTAL • WN ▲ SW-L2 ▲ SW-L1

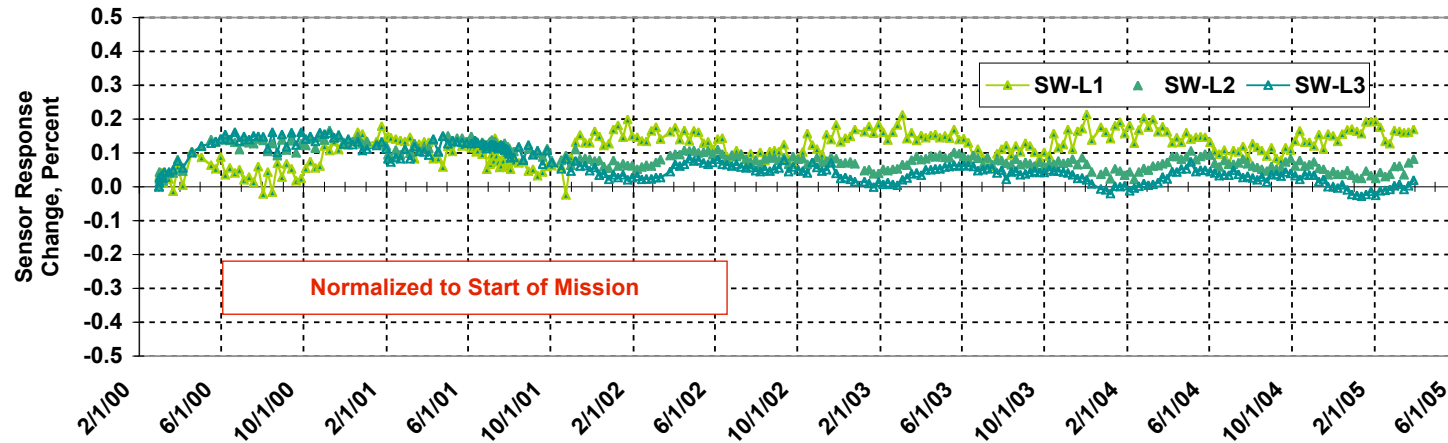


NASA Langley Research Center / Science Directorate

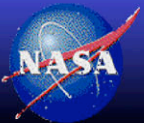
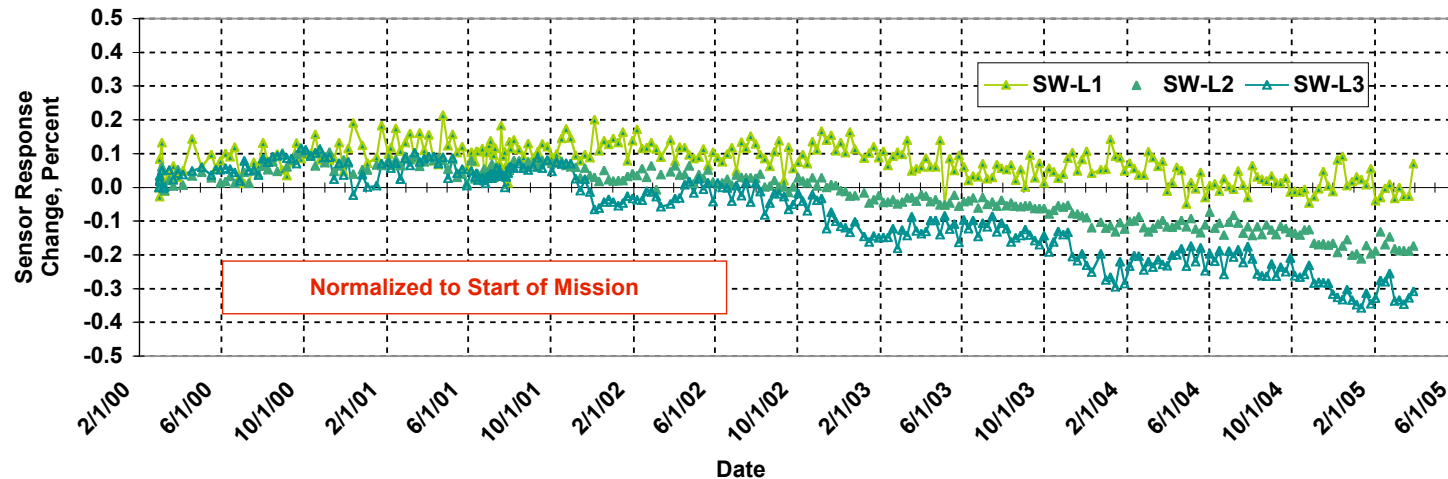


# Terra SW Internal Calibration Results

FM1 In-Flight Internal Calibration Results



FM2 In-Flight Internal Calibration Results



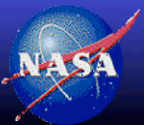
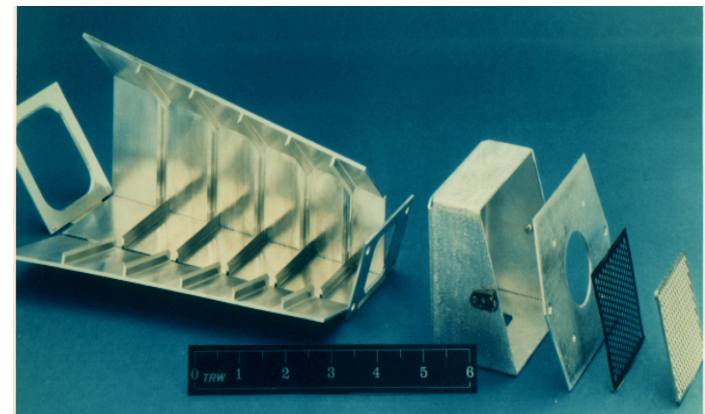
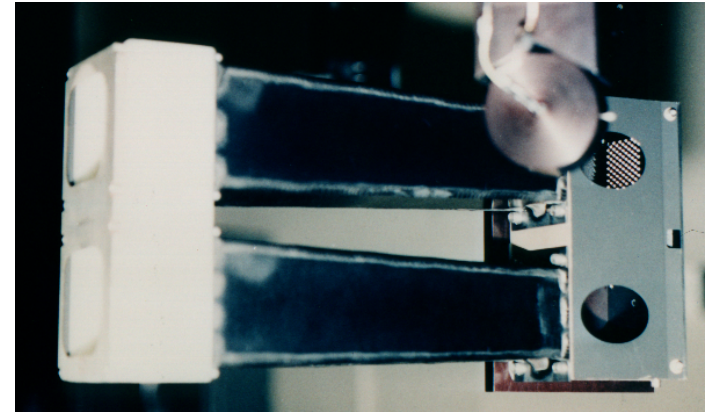
NASA Langley Research Center / Science Directorate



# CERES Solar Calibration

## Mirror Attenuator Mosaic (MAM)

- Solar Diffuser plate attenuates direct solar view
- MAM is a Nickel substrate with Aluminum coated spherical cavities or divots
- Provides a Relative calibration of the Shortwave channel and the SW portion of the Total channel
- Solar Cal results to date are suspect due to large initial drift in MAM surface reflectances...

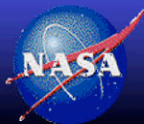
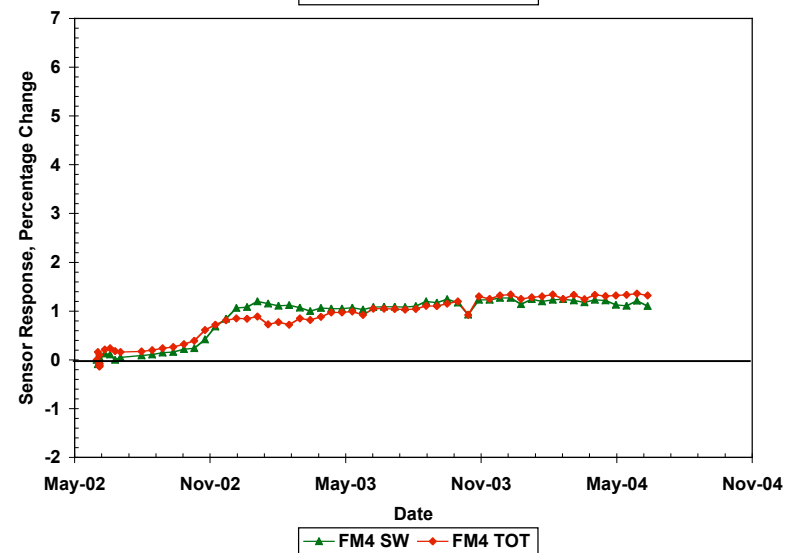
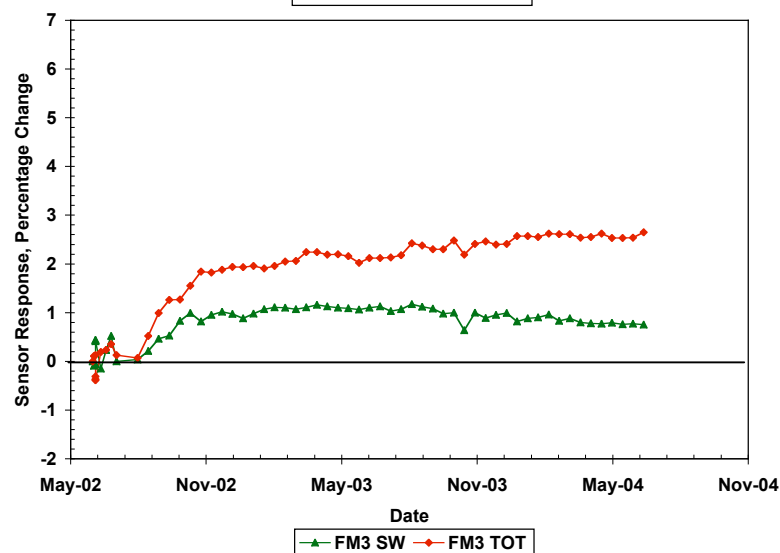
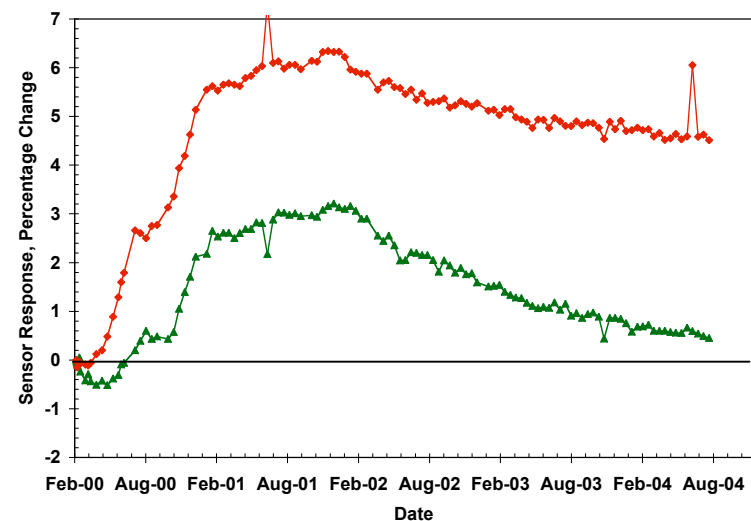
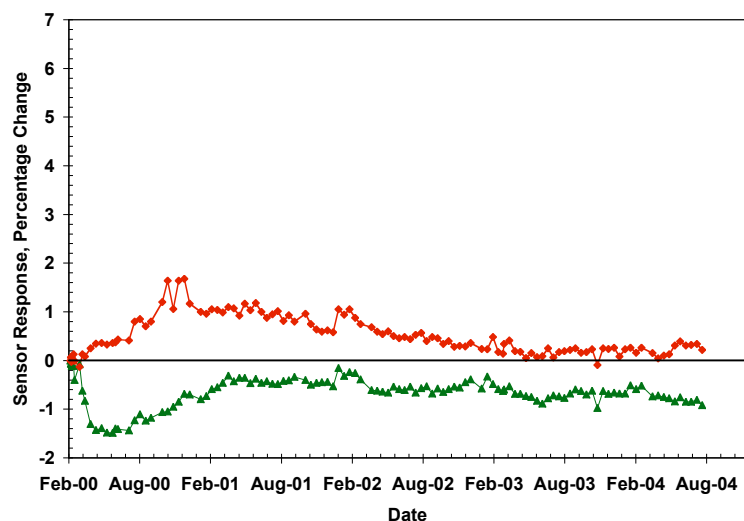


NASA Langley Research Center / Science Directorate





# CERES Solar Calibration Results

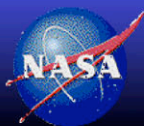
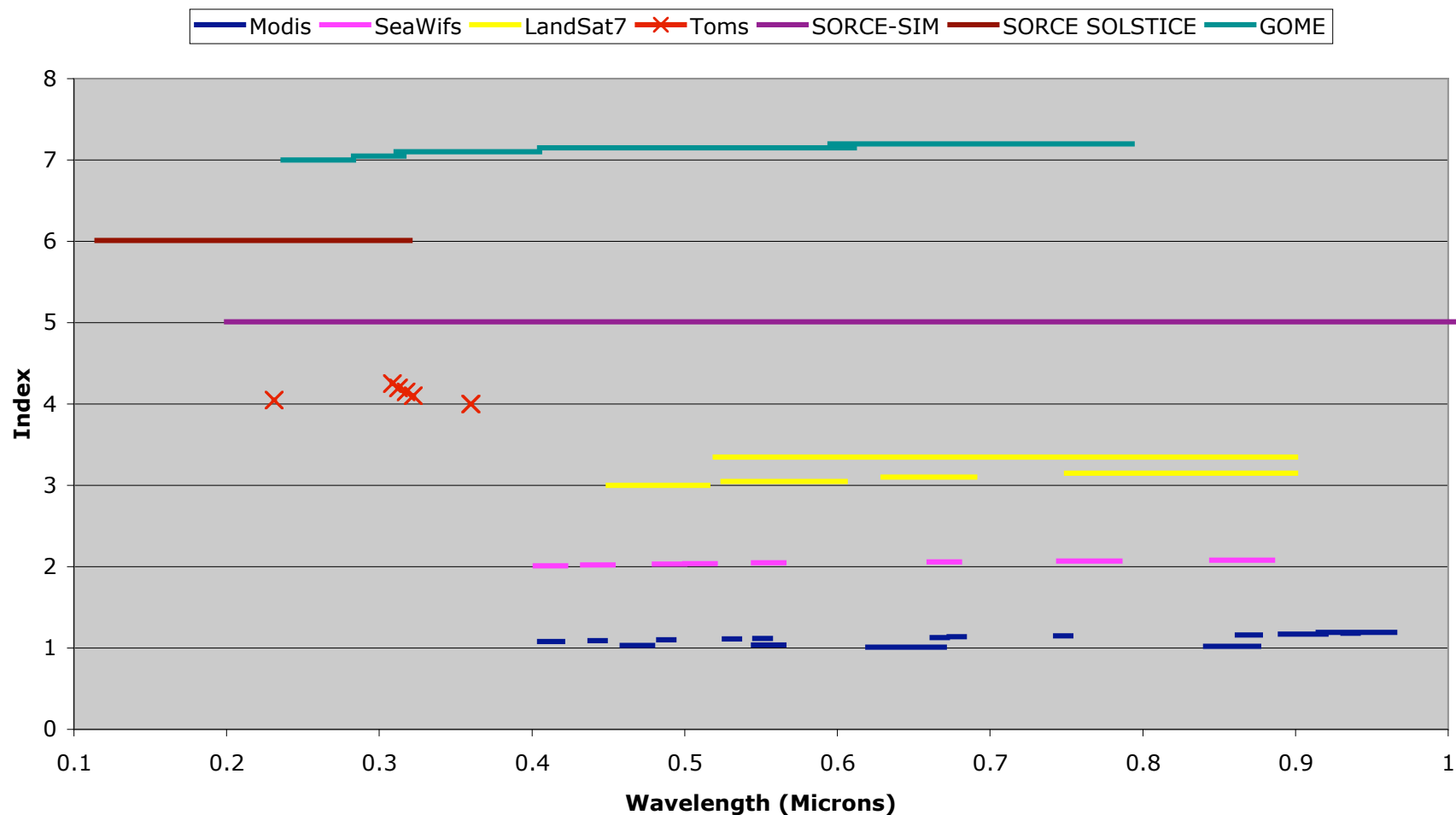


NASA Langley Research Center / Science Directorate



# LEO Missions Subject to Spectral Darkening

## Bandpasses of Selected Instruments



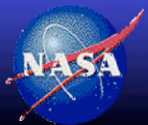
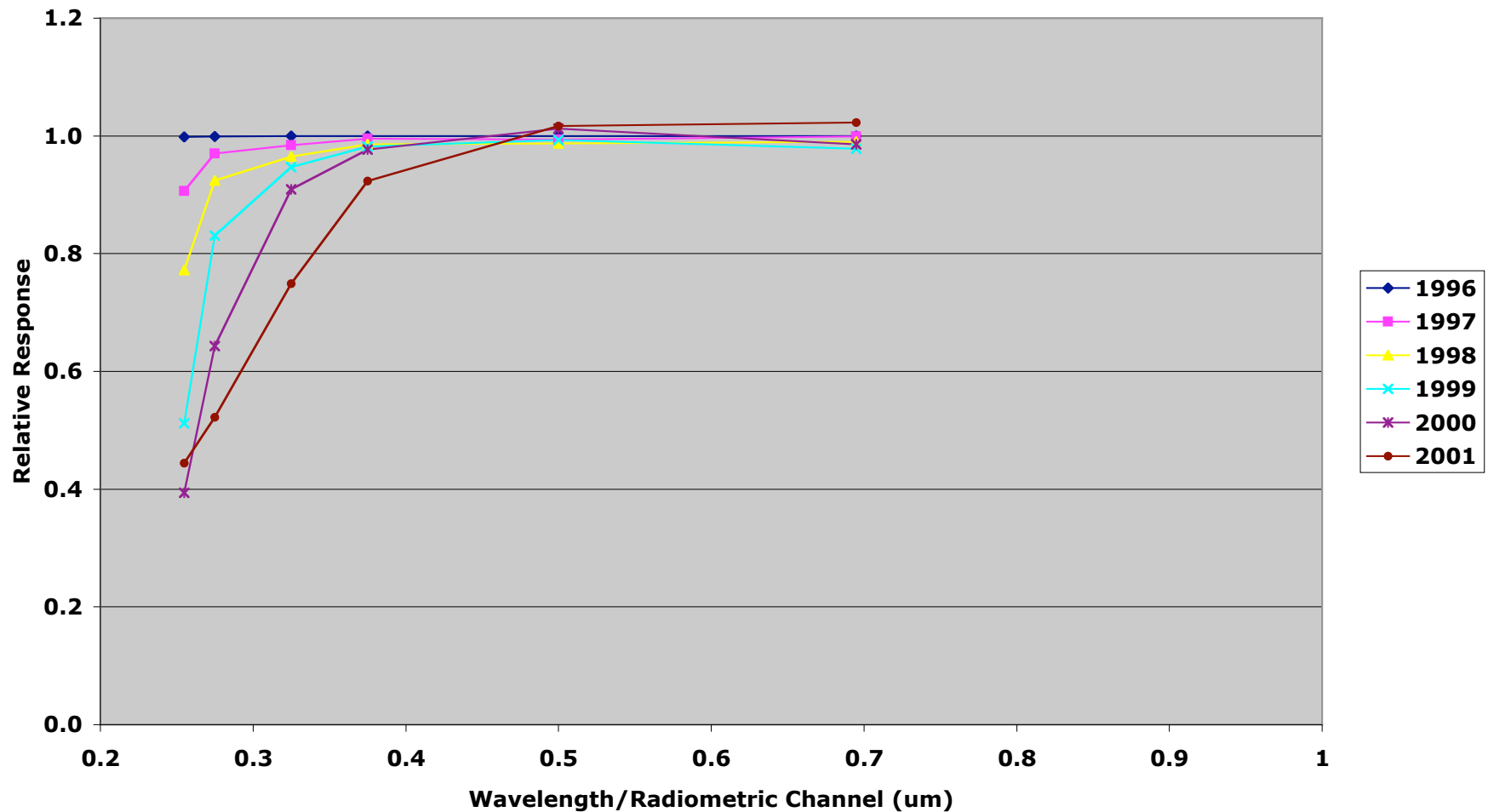
NASA Langley Research Center / Science Directorate





# Spectral Darkening on Similar Missions

Global Ozone Monitoring Experiment (GOME) Spectral Darkening



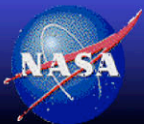
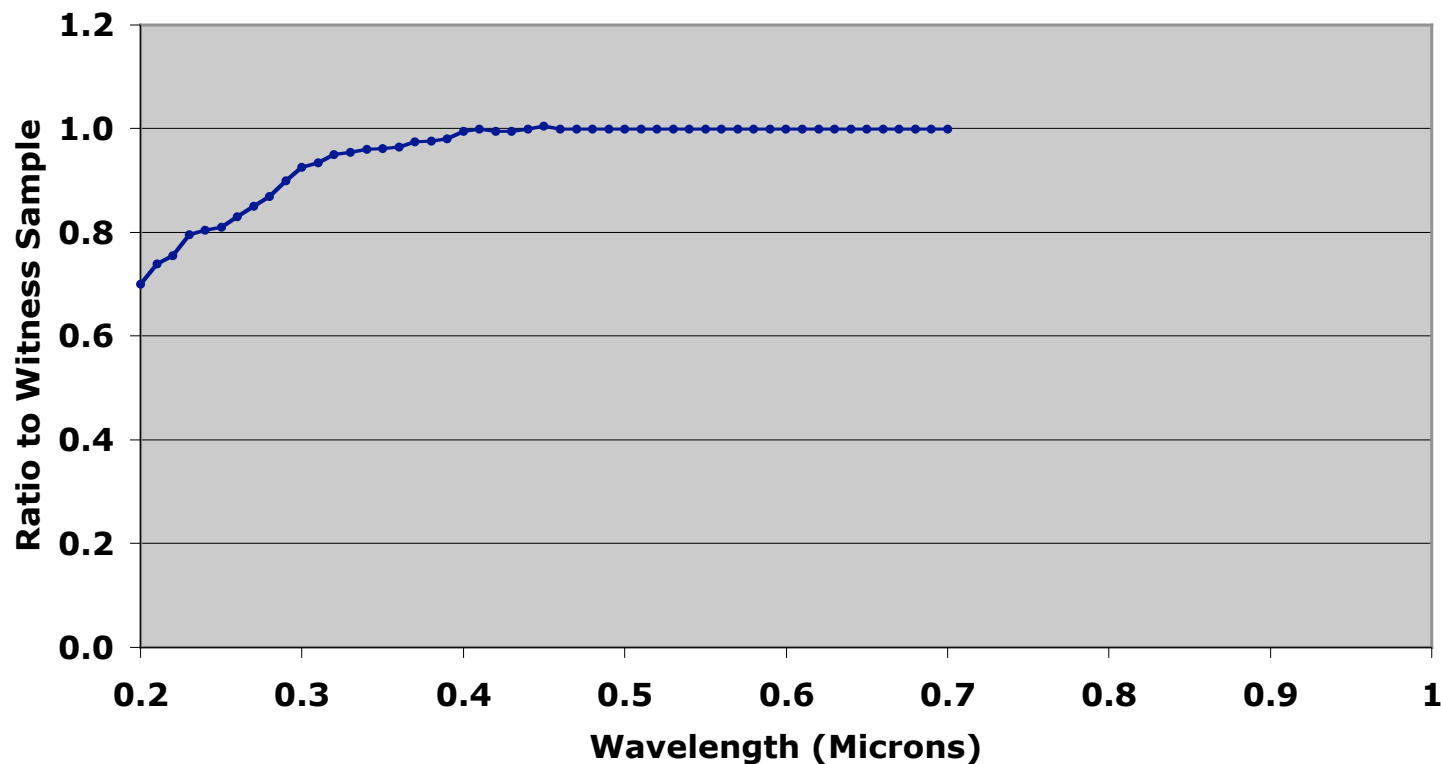
NASA Langley Research Center / Science Directorate



# Spectral Darkening on Similar Missions

## Spare NIMBUS ERB Radiometer flown on LDEF

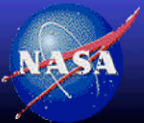
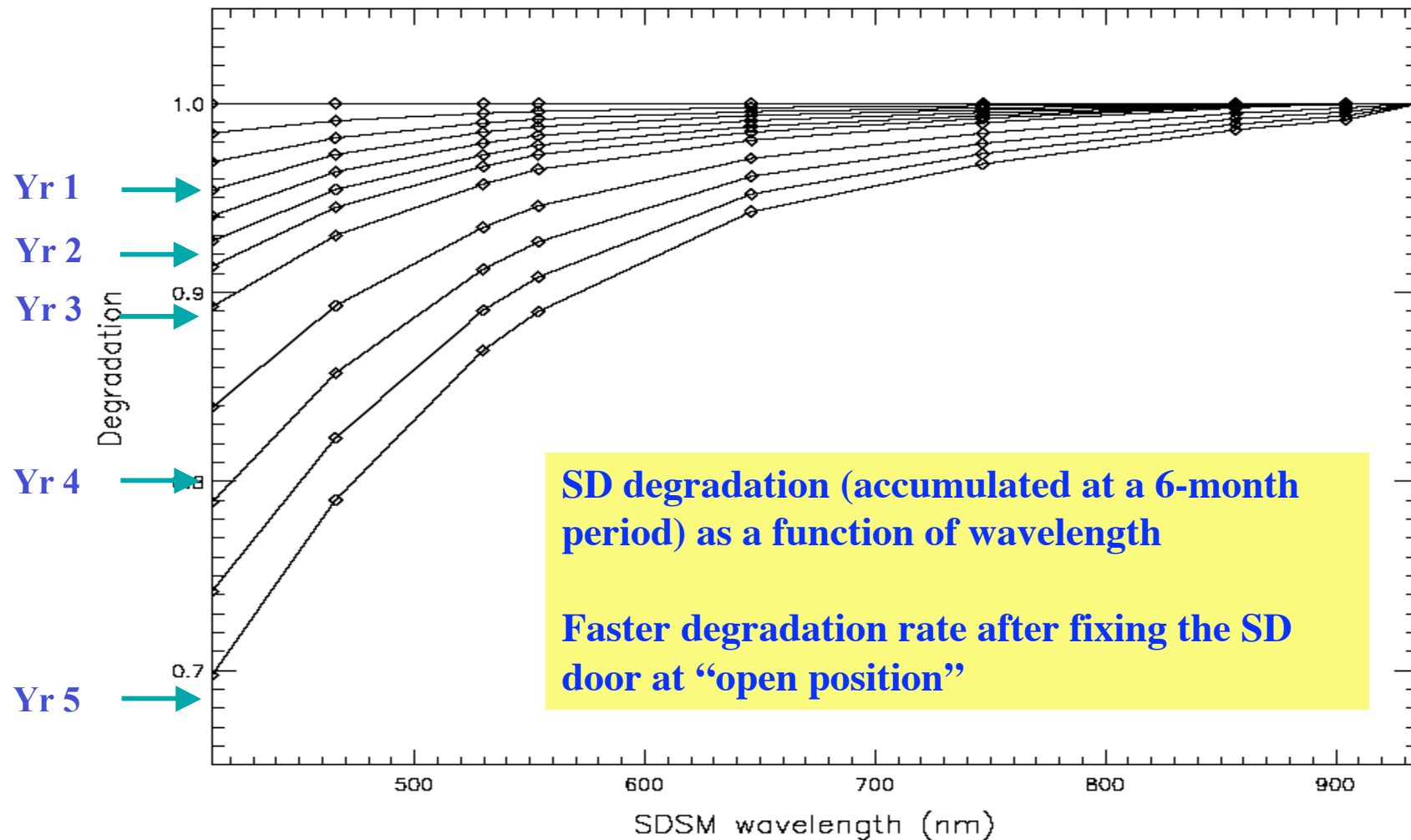
Measured Transmittance Change of Suprasil W  
4mm sample, 5 yr. exposure



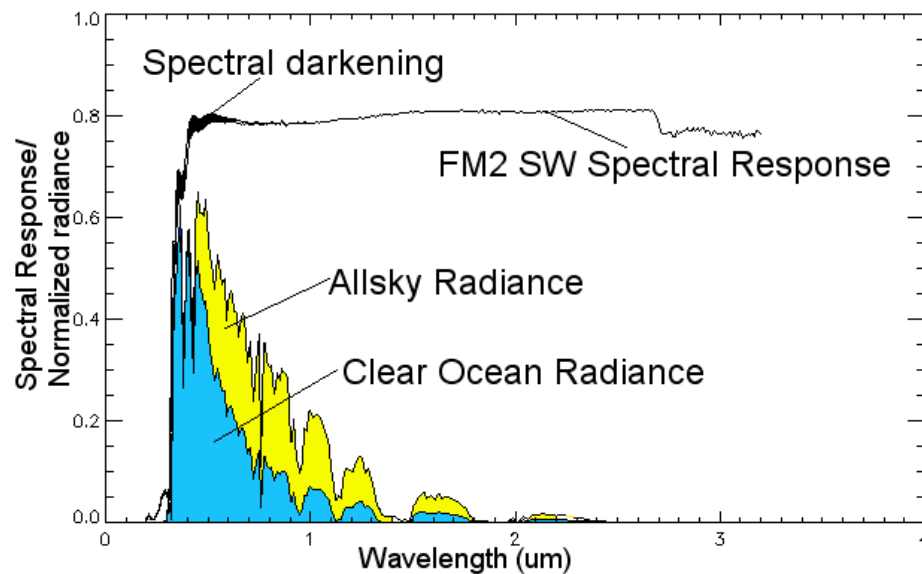
NASA Langley Research Center / Science Directorate



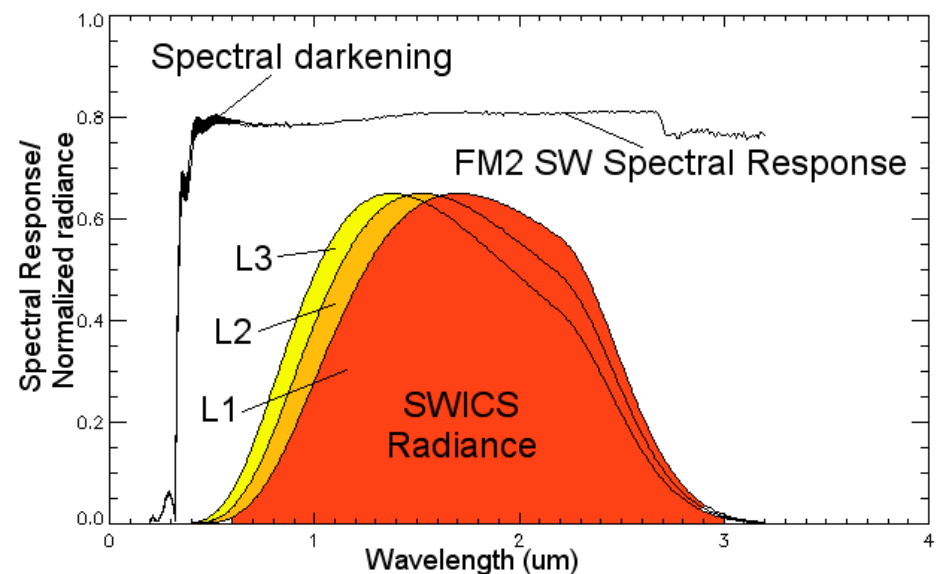
# Modis Solar Diffuser Spectral Degradation



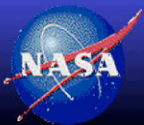
# Spectral Degradation : SWICS vs. Earth Spectra



$$f_{allsky}^{sw} \text{ change } \approx -2\%$$



$$f_{swics}^{sw} \text{ change } \approx -0.1\%$$

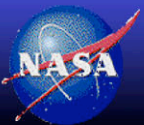
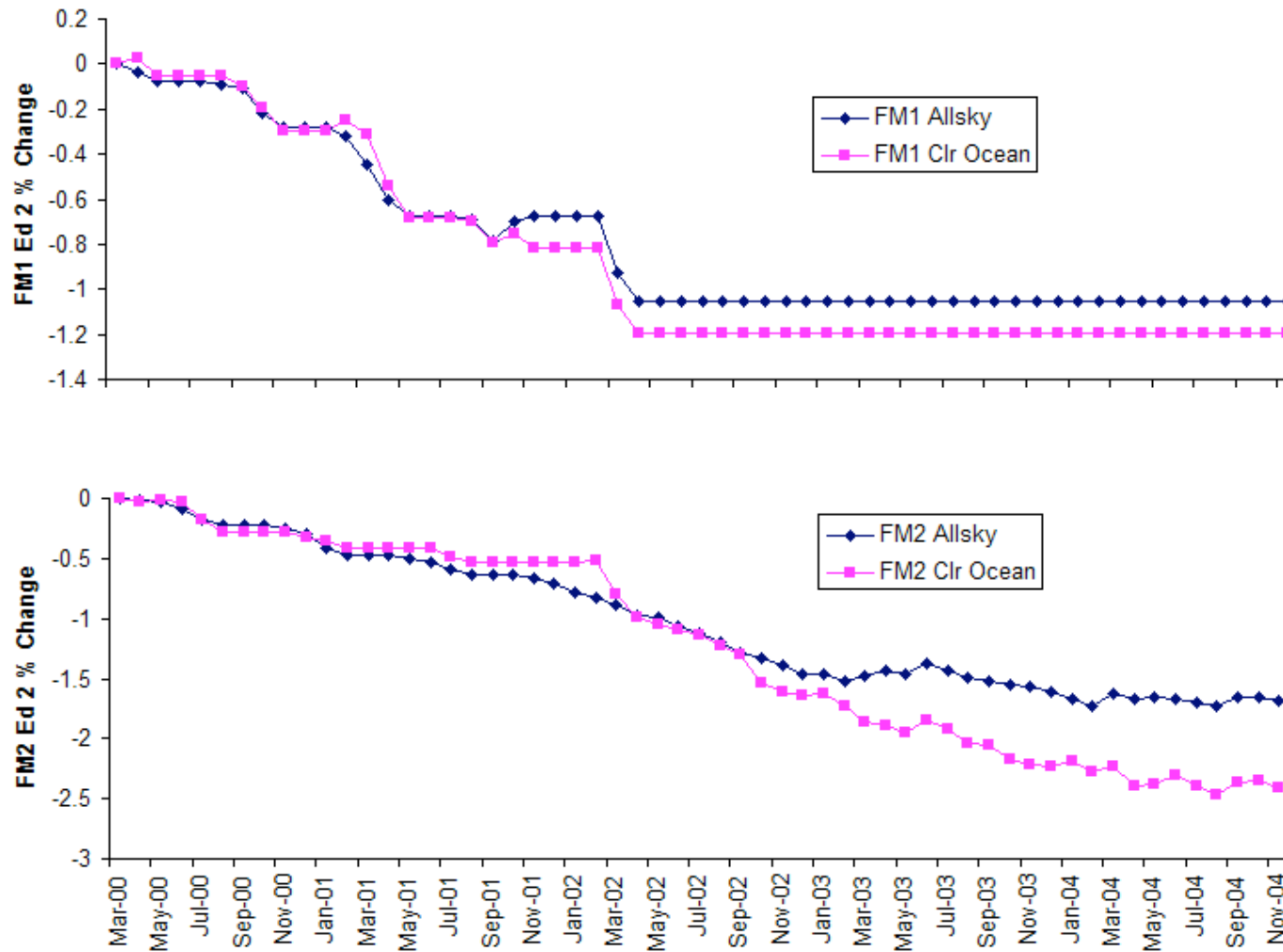


NASA Langley Research Center / Science Directorate



# Edition2\_Rev1 SW Scaling Factors

Use Xtrack instrument as calibration reference to derive Rev1 Scaling Factors



NASA Langley Research Center / Science Directorate



# Edition2\_Rev1 SW Scaling Factors

A table of Rev1 adjustment factors is issued via the quality summary, authors then use the description “Edition2\_Rev1”



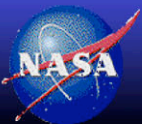
## CERES Terra Revision Table

[2000](#) | [2001](#) | [2002](#) | [2003](#) | [2004](#) | [Tab-delimited file](#)

| Year | Month | All Sky |       | Clear Ocean |       |
|------|-------|---------|-------|-------------|-------|
|      |       | FM1     | FM2   | FM1         | FM2   |
| 2003 | Jan   | 1.011   | 1.015 | 1.012       | 1.017 |
|      | Feb   | 1.011   | 1.015 | 1.012       | 1.018 |
|      | Mar   | 1.011   | 1.015 | 1.012       | 1.019 |
|      | Apr   | 1.011   | 1.014 | 1.012       | 1.019 |
|      | May   | 1.011   | 1.015 | 1.012       | 1.020 |

Multiply your May 03 Terra allsky  
SW fluxes by these values

Multiply your May 03 Terra clear  
ocean SW fluxes by these values



NASA Langley Research Center / Science Directorate

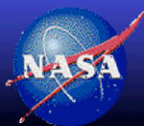


# Terra ES-8 Edition2\_Rev1 Summary

- Cal/Val Protocol demonstrates radiometric stability of the data products through 11/2004 of....

|         | Edition1 |      | Edition2 |      | Edition2_Rev1 |      |
|---------|----------|------|----------|------|---------------|------|
|         | FM1      | FM2  | FM1      | FM2  | FM1           | FM2  |
| LWday   | .3       | .6   | .125     | .125 | .125          | .125 |
| LWnight | .1       | .125 | <.1      | <.1  | <.1           | <.1  |
| SW      | .2       | .4   | .2       | .3   | .1            | .1   |
| WN      | <.1      | <.1  | <.1      | <.1  | <.1           | <.1  |

Note: Values apply to all-sky global averages  
Units are in %/yr



NASA Langley Research Center / Science Directorate



# Terra ES-8 Edition2\_Rev1 Summary

- Cal/Val Protocol demonstrates radiometric stability of the data products through 11/2004 of....

|         | Edition1 |      | Edition2 |      | Edition2_Rev1 |      |
|---------|----------|------|----------|------|---------------|------|
|         | FM1      | FM2  | FM1      | FM2  | FM1           | FM2  |
| LWday   | .3       | .6   | .125     | .125 | .125          | .125 |
| LWnight | .1       | .125 | <.1      | <.1  | <.1           | <.1  |
| SW      | .2       | .4   | .2       | .3   | .1            | .1   |
| WN      | <.1      | <.1  | <.1      | <.1  | <.1           | <.1  |

Note: Values apply to all-sky global averages  
Units are in %/yr



NASA Langley Research Center / Science Directorate



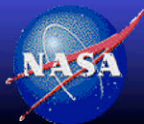


# CERES Gain/Spectral Change Summary

**Cumulative changes incorporated in Edition 2 BDS and ERBE-Like products**

| Spacecraft |     | Channel Gain (%) |    |     | Channel Spectral Response (%) |    |        |        | TOA Flux All-Sky (W/m <sup>2</sup> ) |       |         |
|------------|-----|------------------|----|-----|-------------------------------|----|--------|--------|--------------------------------------|-------|---------|
|            |     | TOT              | WN | SW  | SW                            | WN | SW/TOT | LW/TOT | SW                                   | LWDay | LWNight |
| Terra      | FM1 | .35              | -  | -   | -                             | -  | .45    | -      | -                                    | 1.1   | .65     |
|            | FM2 | .40              | -  | -   | .40                           | -  | 2.6    | -      | .4                                   | 3.6   | 1.0     |
| Aqua       | FM3 | .45              | -  | .50 | -                             | -  | 1.4    | -      | .5                                   | 1.6   | 1.1     |
|            | FM4 | .30              | -  | .80 | -                             | -  | 1.2    | -      | .7                                   | 1.6   | .75     |

1. All values are maximum on-orbit changes
2. Ground to flight shifts are accounted for separately
3. SW/TOT < 3.0 microns, LW/TOT > 3.0 microns
4. TOA Flux values are all-sky global averages



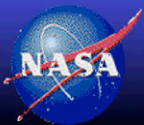
NASA Langley Research Center / Science Directorate



---

# **Derivation of Edition 3 SW Spectral Response**

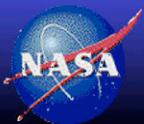
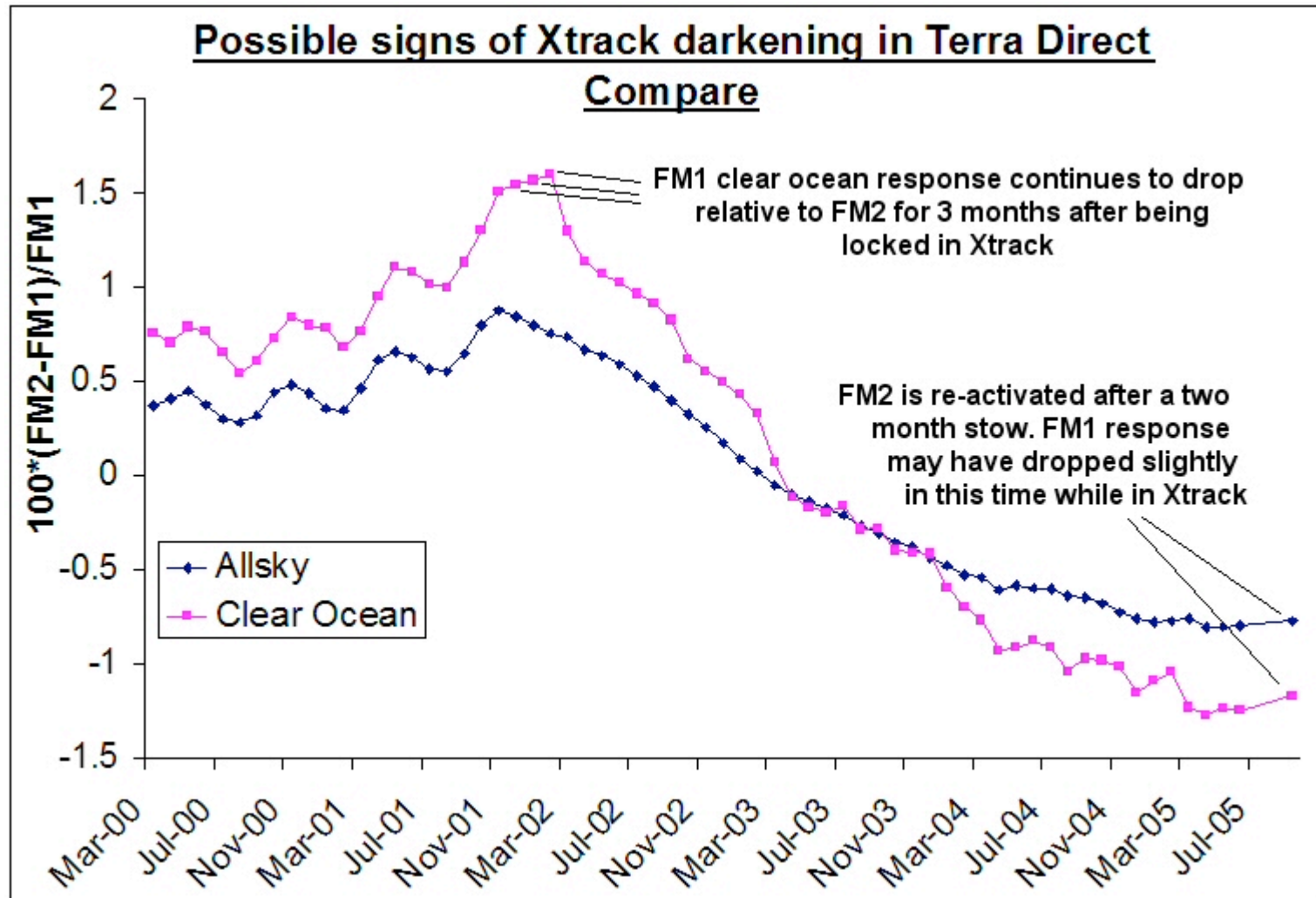
**CERES Instrument Working Group  
CERES STM, 1 Nov 05, Hampton, VA**



**NASA Langley Research Center / Science Directorate**



Rev1 adjustment removes the drift assuming the Xtrack instrument is stable. Some unexplained features in direct compare suggest this may not be the case:



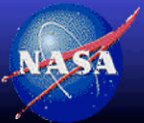
NASA Langley Research Center / Science Directorate

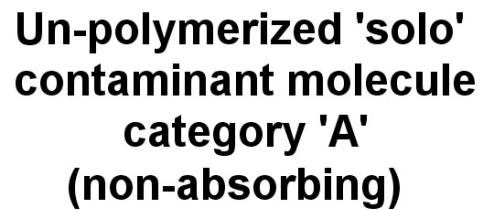


---

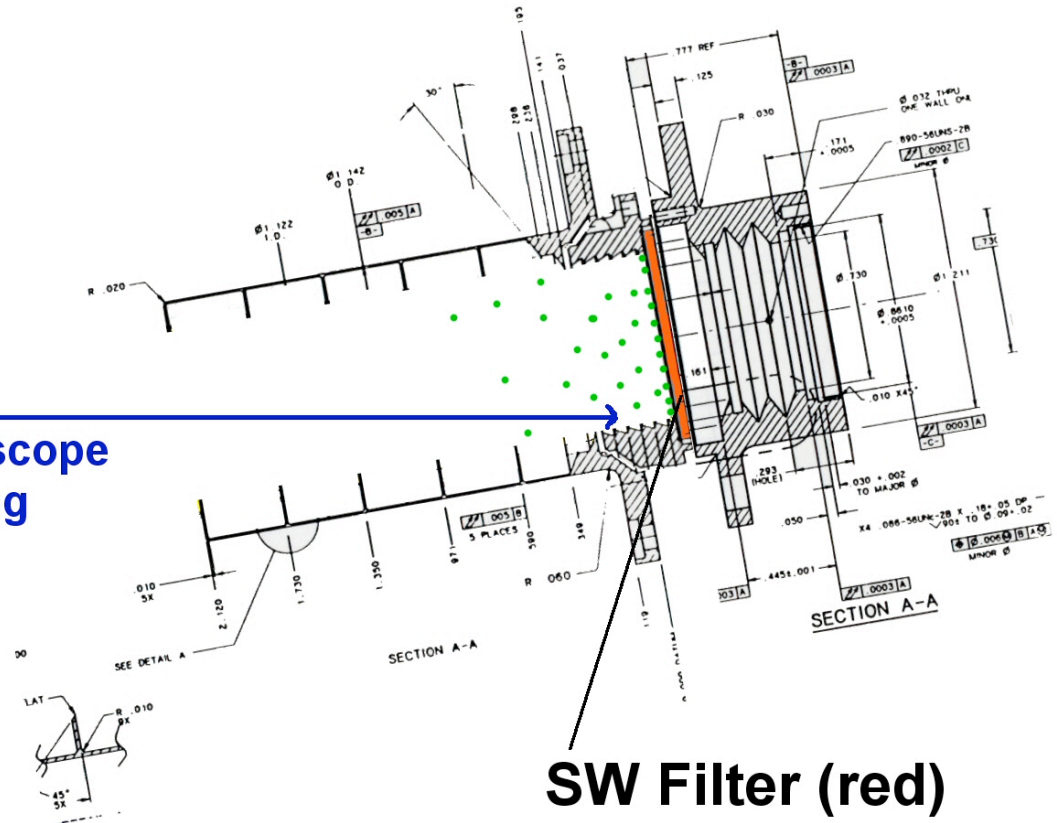
In order to fully compensate for darkening effects in the Edition 3 spectral response the following activities are underway:

- **Further stows are planned to directly measure any Xtrack darkening**
- **New reduced noise full swath direct compare data using both instruments in Xtrack is under production**
- **A physical model of the contaminant deposition and subsequent darkening is being developed and tuned to internal calibration and direct compare data. This will incorporate results from further stows and noise reduced direct compare**





**Space bound particles enter telescope  
when in RAM direction, freeing  
contaminant molecules  
to be fixed to filter  
by Earth UV**



---

**Photons tend to interact with targets of similar size to their wavelength, hence contaminant absorption can be modeled as:**

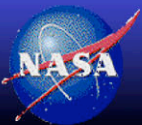
$$a(\lambda) = H \times (\text{number of molecules in a polymer chain of length } \lambda)$$

**Might expect population density of polymer chain length to fall off exponentially:**

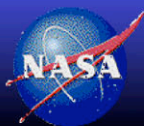
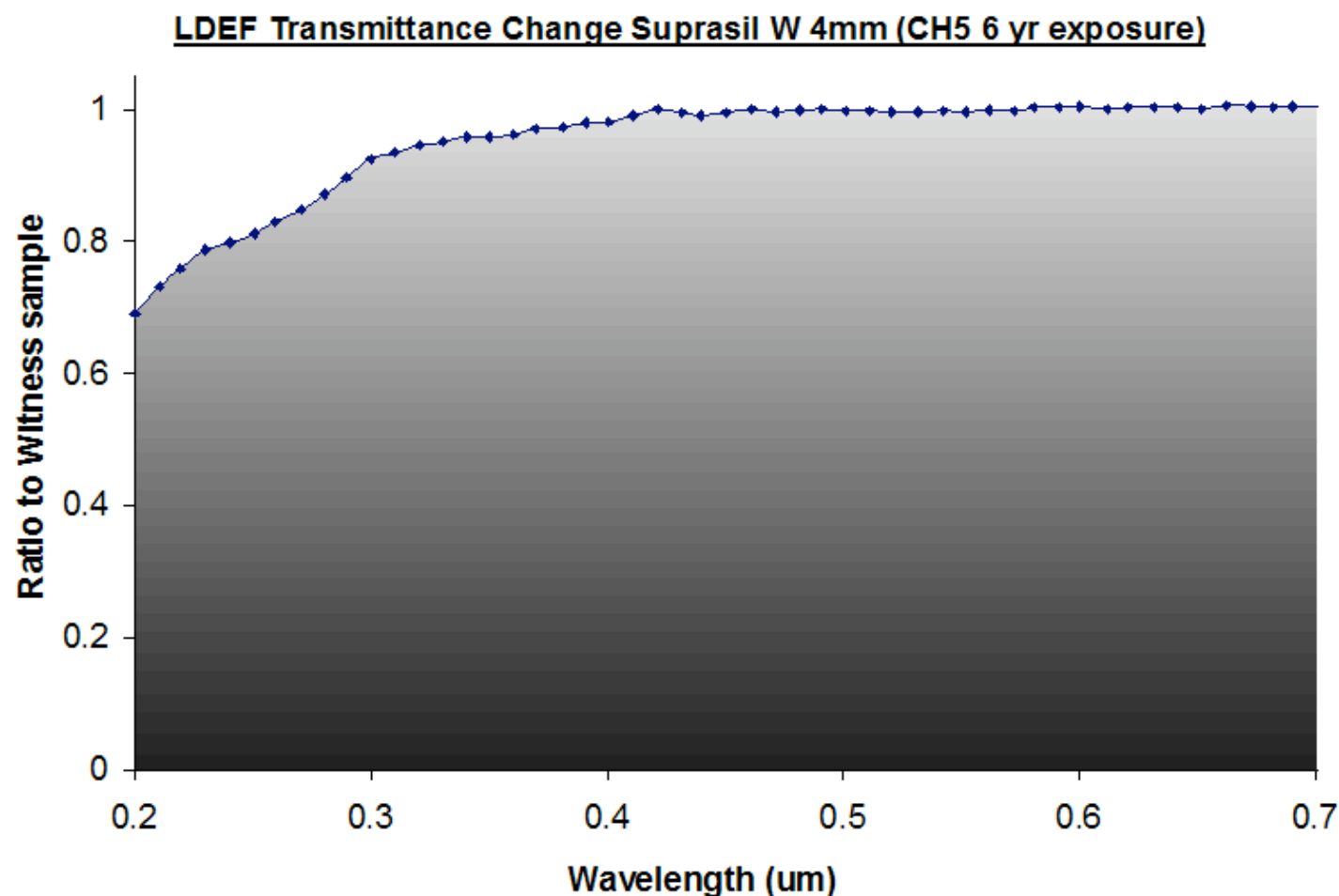
$$a(\lambda) = H \times e^{-\alpha\lambda}$$

$$T(\lambda) = 1 - a(\lambda)$$

$$T(\lambda) = 1 - H.e^{-\alpha\lambda}$$



This fits the basic shape of spectral darkening seen on LDEF, GOME and MODIS:  $T(\lambda) = 1 - H.e^{-\alpha\lambda}$

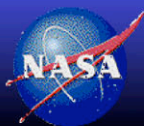
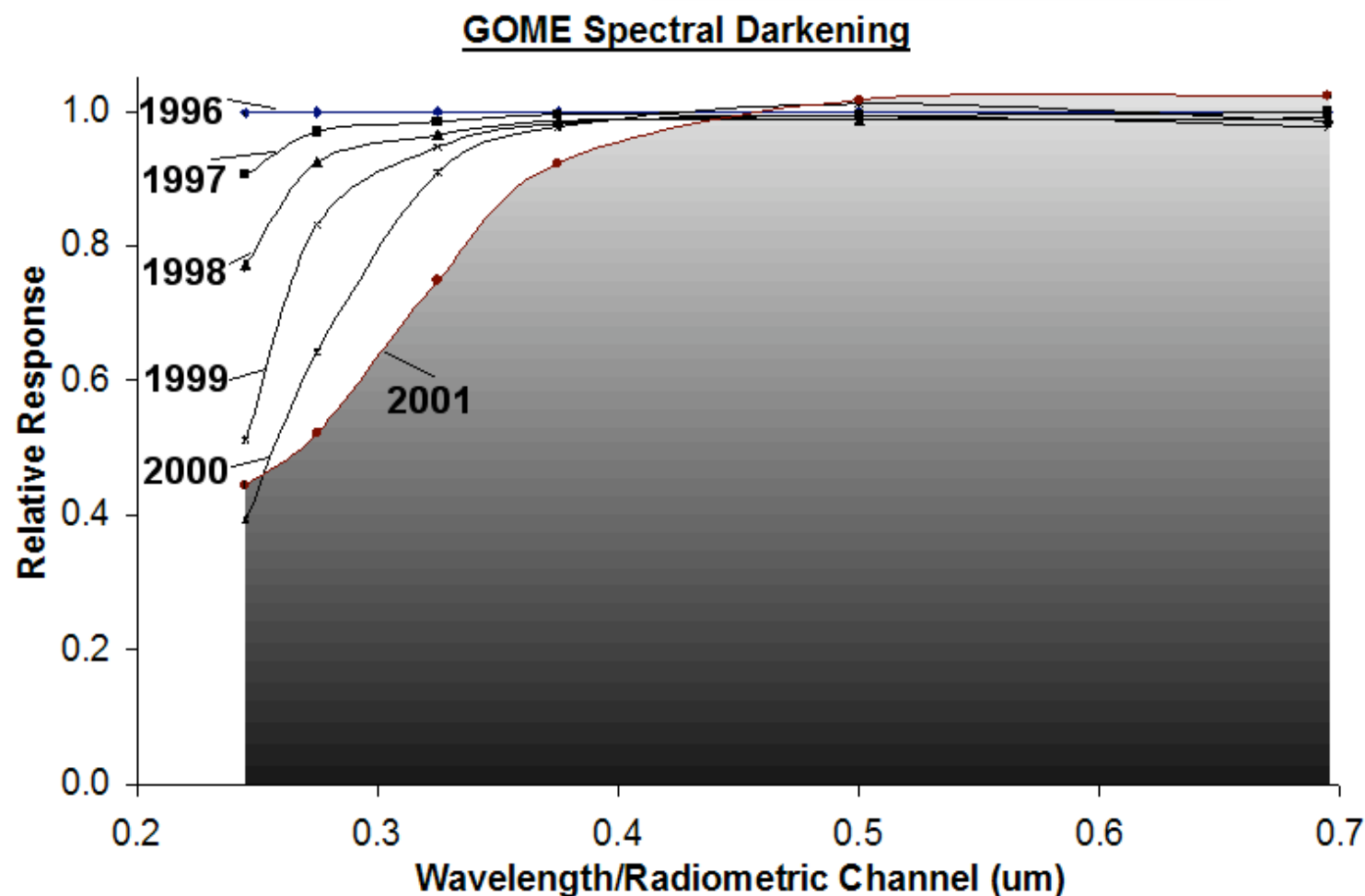


NASA Langley Research Center / Science Directorate



This fits the basic shape of spectral darkening seen on LDEF, GOME and MODIS:

$$T(\lambda) = 1 - H.e^{-\alpha\lambda}$$

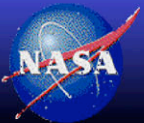
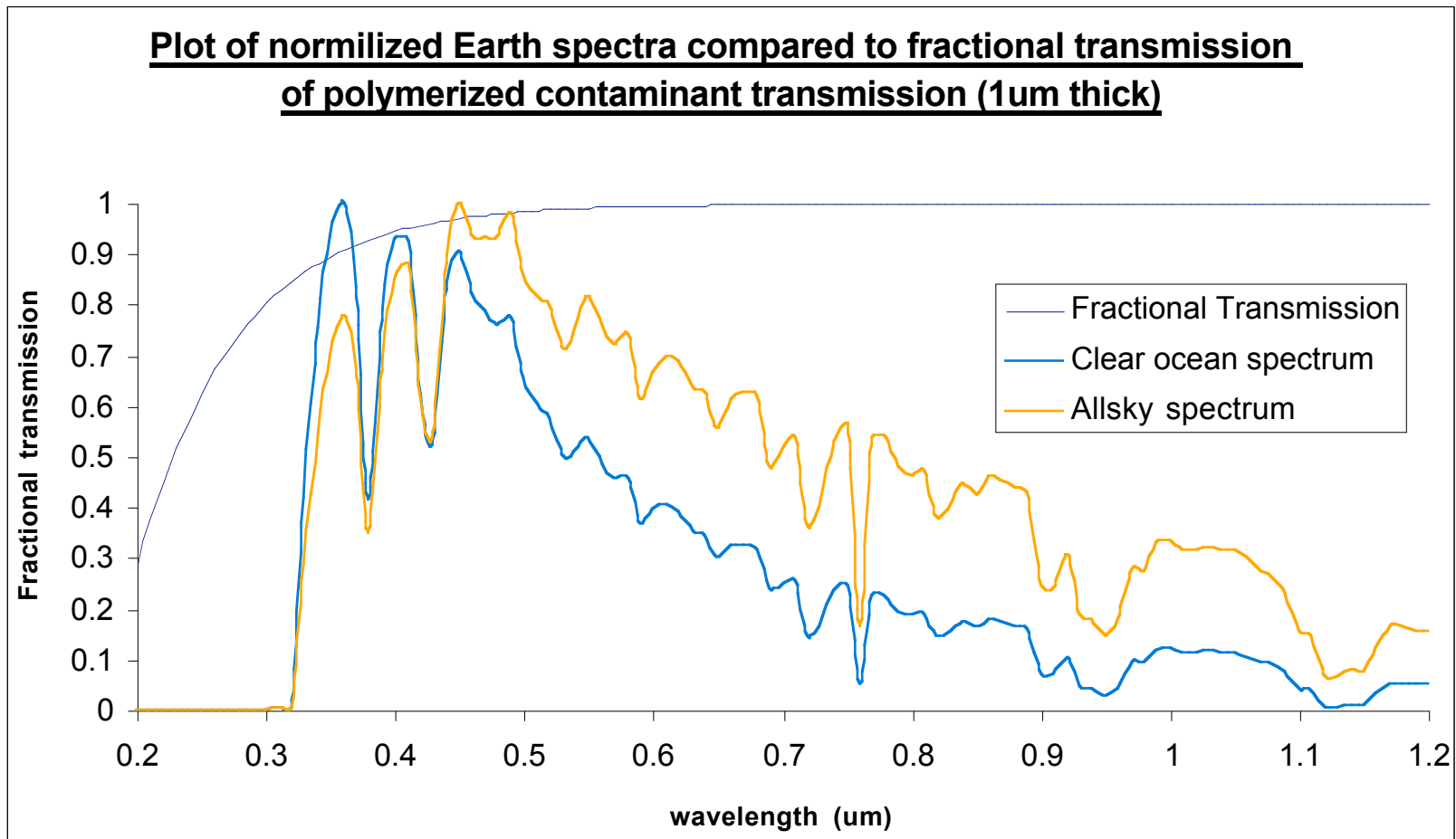


NASA Langley Research Center / Science Directorate





So 1 um thickness of polymerized contaminant might have a transmission given by:  $T(\lambda) = 1 - 0.71.e^{-12.95\lambda}$



NASA Langley Research Center / Science Directorate

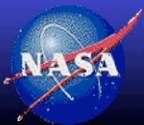


---

**Experience from LDEF suggests that continued exposure of contaminants to UV photons increases the polymerization, making the remaining category 'A' solo molecules form more absorbing long chains (becoming category 'B')**


$$\frac{dB}{dt} = 0.008 [N - B] + 0.4 \frac{dN}{dt}$$

**If N is the total number of contaminant molecules (A+B), this equation represents a situation where 40% of molecules arriving per day of RAPs are already polymerized (category B). Every day earth UV also converts 0.8% of the remaining category A molecules to category B**



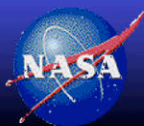
---

 **Polymerized absorbing  
contaminant molecule  
(category B)**

 **Un-polymerized contaminant  
molecule (non-absorbing  
category A)**

# RAPS

  
**Contaminant Thickness**



**NASA Langley Research Center / Science Directorate**



Read in the  
modes for each  
instrument and  
use them to  
generate forcing  
( $dN/dt$ ) for arrival  
of contaminant at  
each instrument  
filter surface

TERRA DAILY INSTRUMENT MODE SEQUENCE - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Home Search Favorites Refresh Print View Source

Address [http://earth-www.larc.nasa.gov/ceresweb/INSTRUMENT/terra\\_daily\\_modes.html](http://earth-www.larc.nasa.gov/ceresweb/INSTRUMENT/terra_daily_modes.html)

# INSTRUMENT WORKING GROUP

## CLOUDS AND THE EARTH'S RADIANT ENERGY SYSTEM

### DAILY INSTRUMENT MODE SEQUENCE

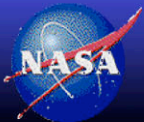
DATES : MISSION LIFETIME  
SPACECRAFT : TERRA (Click [HERE](#) for spacecraft events.)  
INSTRUMENT : FM1 (CEF) and FM2 (CEA)

These mode sequences indicate the instruments' daily predominate, nominal operational mode.  
Click [HERE](#) for additional operational details.

Last Updated: 10/27/2005 12:58:31

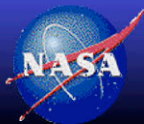
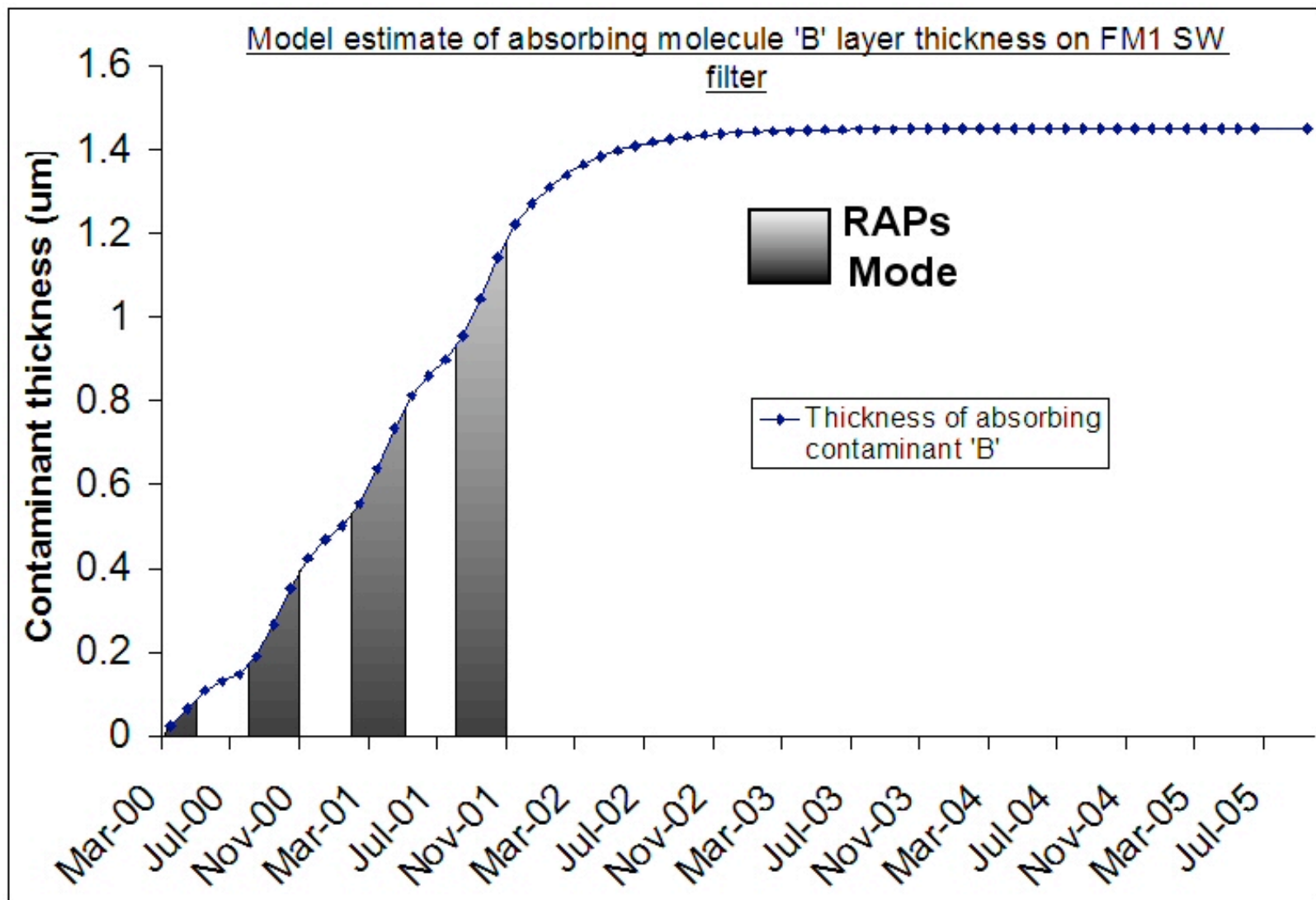
| DATE       | FM1_INSTRUMENT | FM2_INSTRUMENT |
|------------|----------------|----------------|
| MARCH 2000 |                |                |
| 03/01/00   | RAPS 1         | XTRACK 0       |
| 03/02/00   | XTRACK 0       | XTRACK 0       |
| 03/03/00   | XTRACK 0       | RAPS 1         |
| 03/04/00   | RAPS 1         | XTRACK 0       |
| 03/05/00   | XTRACK 0       | XTRACK 0       |
| 03/06/00   | XTRACK 0       | RAPS 1         |
| 03/07/00   | RAPS 1         | XTRACK 0       |
| 03/08/00   | XTRACK 0       | XTRACK 0       |
| 03/09/00   | XTRACK 0       | RAPS 1         |
| 03/10/00   | RAPS 1         | XTRACK 0       |
| 03/11/00   | XTRACK 0       | XTRACK 0       |
| 03/12/00   | XTRACK 0       | RAPS 1         |
| 03/13/00   | XTRACK 0       | XTRACK 0       |
| 03/14/00   | XTRACK 0       | XTRACK 0       |
| 03/15/00   | XTRACK 0       | XTRACK 0       |
| 03/16/00   | RAPS 1         | XTRACK 0       |
| 03/17/00   | XTRACK 0       | XTRACK 0       |
| 03/18/00   | XTRACK 0       | RAPS 1         |
| 03/19/00   | RAPS 1         | XTRACK 0       |
| 03/20/00   | XTRACK 0       | XTRACK 0       |
| 03/21/00   | XTRACK 0       | RAPS 1         |
| 03/22/00   | RAPS 1         | XTRACK 0       |
| 03/23/00   | XTRACK 0       | XTRACK 0       |
| 03/24/00   | XTRACK 0       | RAPS 1         |
| 03/25/00   | RAPS 1         | XTRACK 0       |
| 03/26/00   | XTRACK 0       | XTRACK 0       |
| 03/27/00   | XTRACK 0       | RAPS 1         |
| 03/28/00   | RAPS 1         | XTRACK 0       |
| 03/29/00   | XTRACK 0       | XTRACK 0       |
| 03/30/00   | XTRACK 0       | RAPS 1         |
| 03/31/00   | RAPS 1         | XTRACK 0       |
| APRIL 2000 |                |                |
| 04/01/00   | RAPS 1         | XTRACK 0       |
| 04/02/00   | RAPS 1         | XTRACK 0       |
| 04/03/00   | RAPS 1         | XTRACK 0       |
| 04/04/00   | RAPS 1         | XTRACK 0       |
| 04/05/00   | RAPS 1         | XTRACK 0       |

(SunRise SolCal: FM1-00:43 UTC, FM2-01:28 UTC)  
(SunRise SolCal: FM1-01:28 UTC, FM2-01:26 UTC)  
(SunRise SolCal: FM1-00:06 UTC, FM2-00:08 UTC)



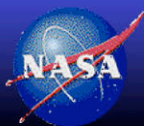
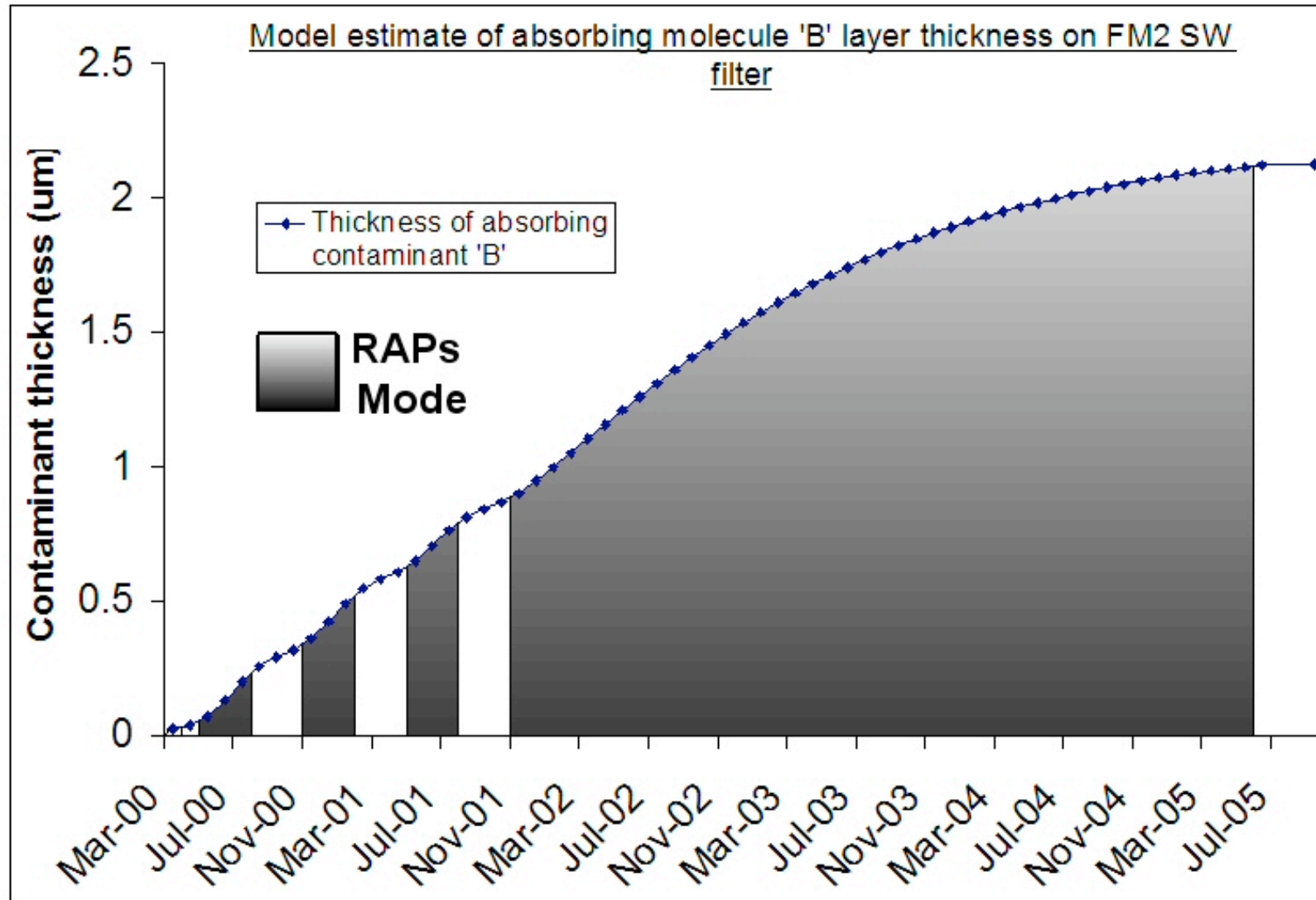
NASA Langley Research Center / Science Directorate



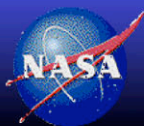
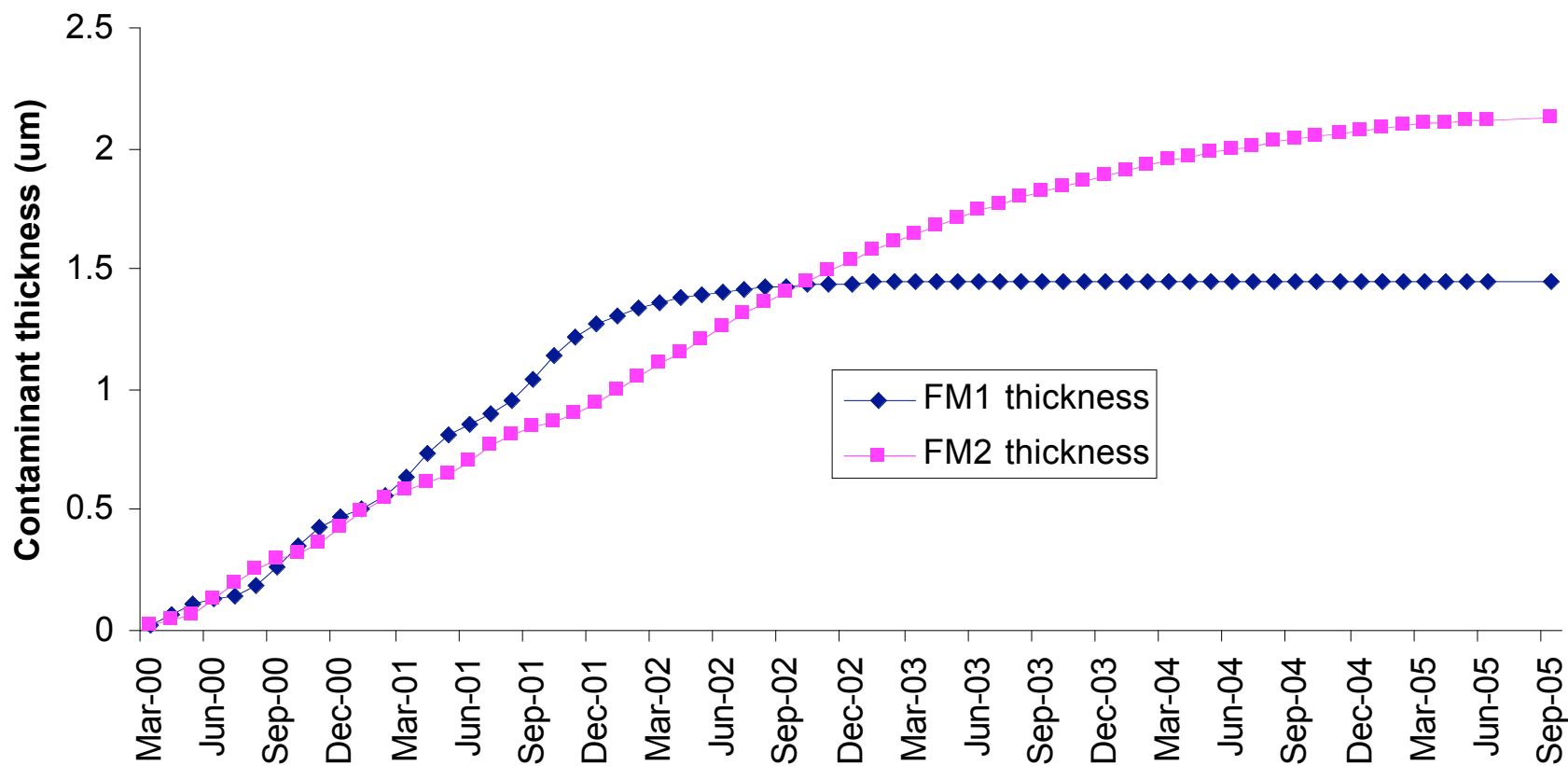


NASA Langley Research Center / Science Directorate





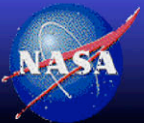
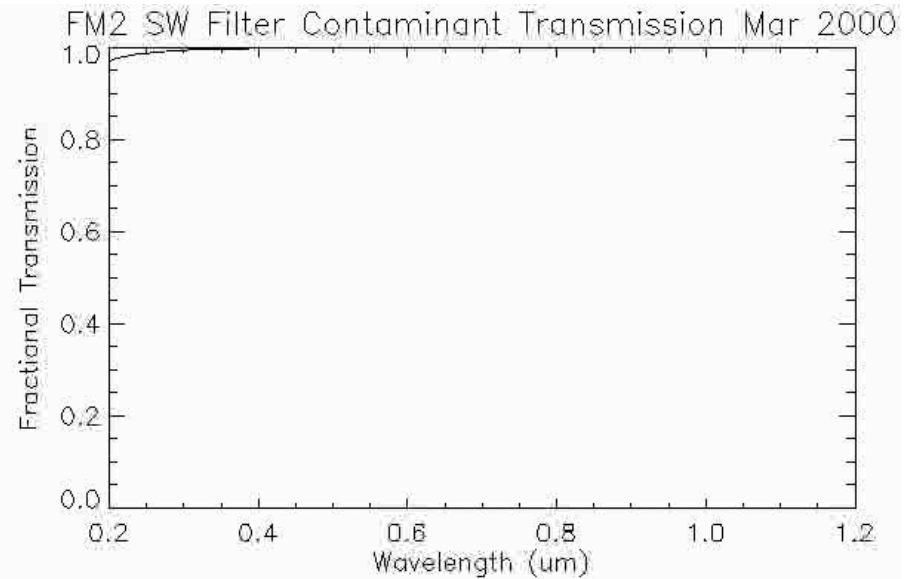
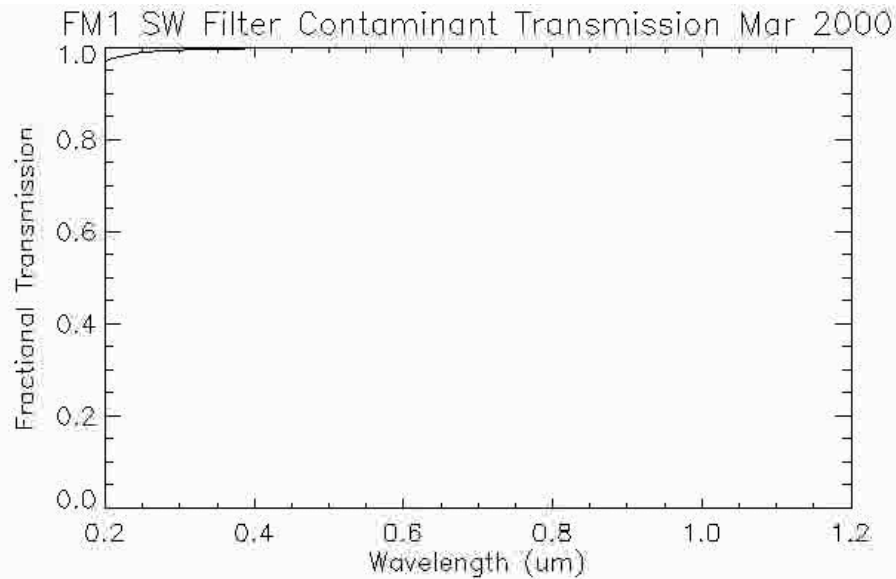
**Model estimate of absorbing molecule 'B' layer thickness on Terra**  
**SW filters**



NASA Langley Research Center / Science Directorate



Hence the contaminant transmission can now be found  
throughout the mission:  $T(\lambda) = [1 - 0.71.e^{-12.95\lambda}]^{thickness}$

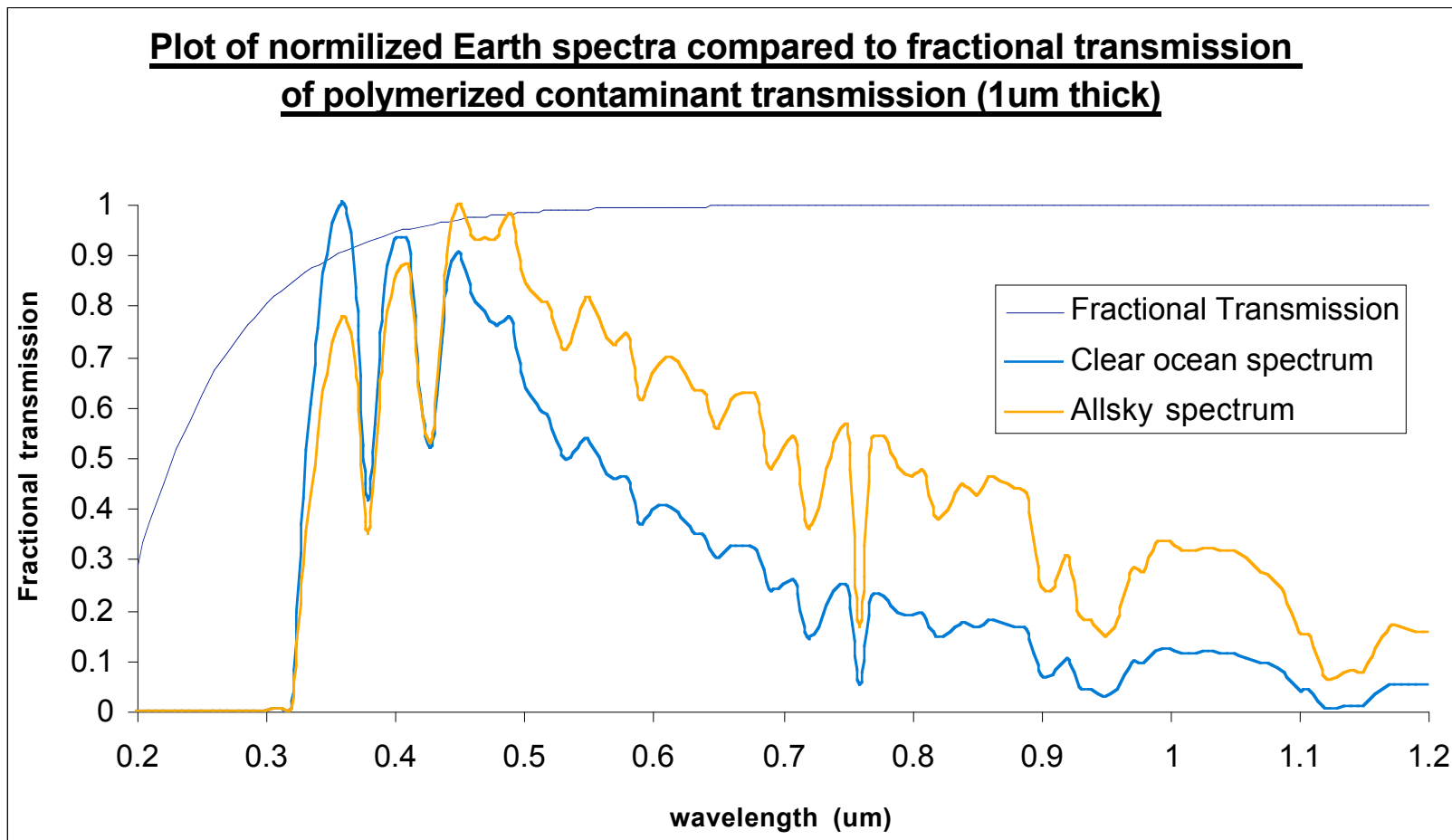


NASA Langley Research Center / Science Directorate





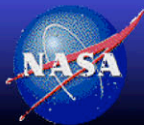
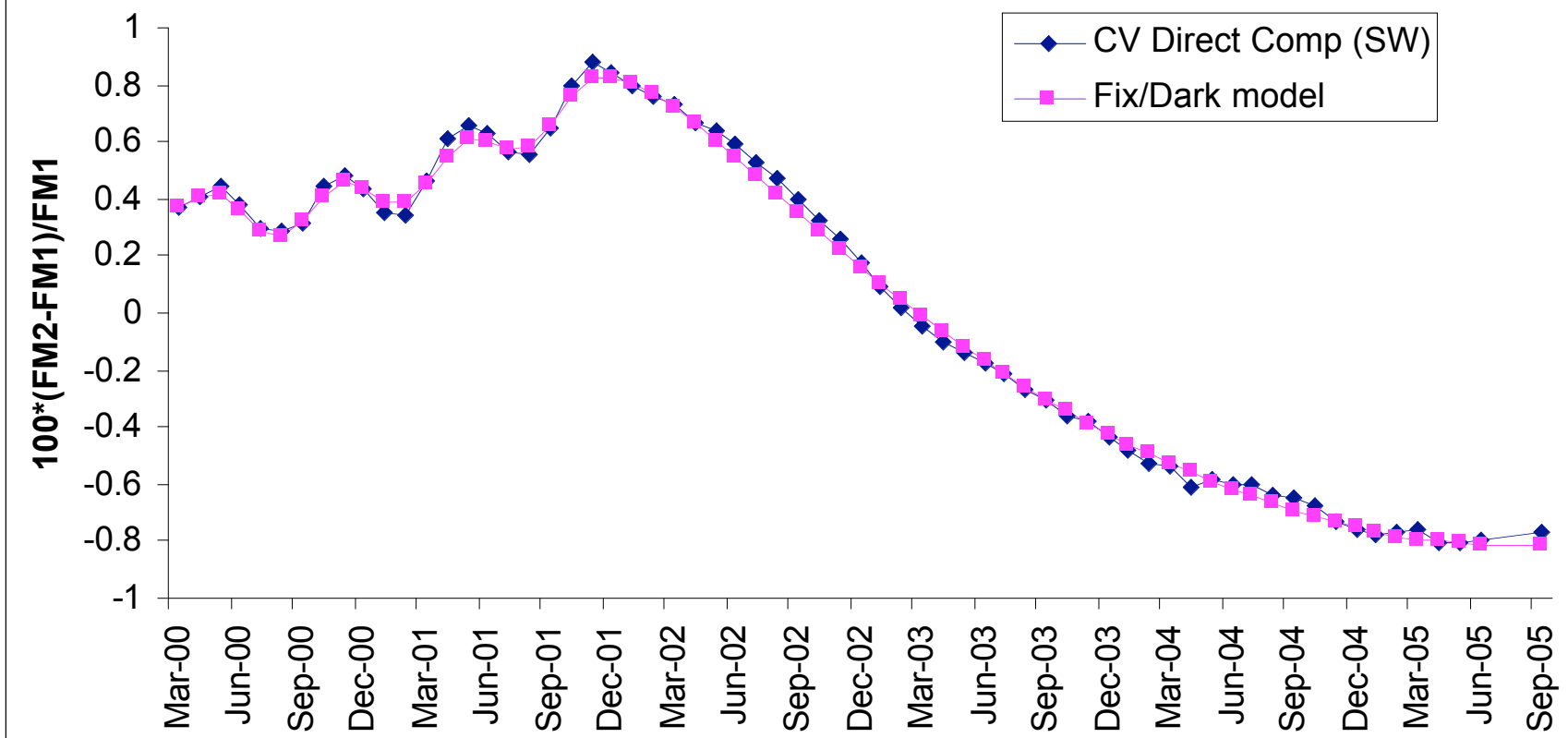
**Tune the model so its estimate of changes to filtered radiance matches the internal calibration lamps and direct compare:**



NASA Langley Research Center / Science Directorate



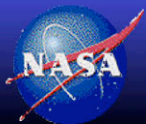
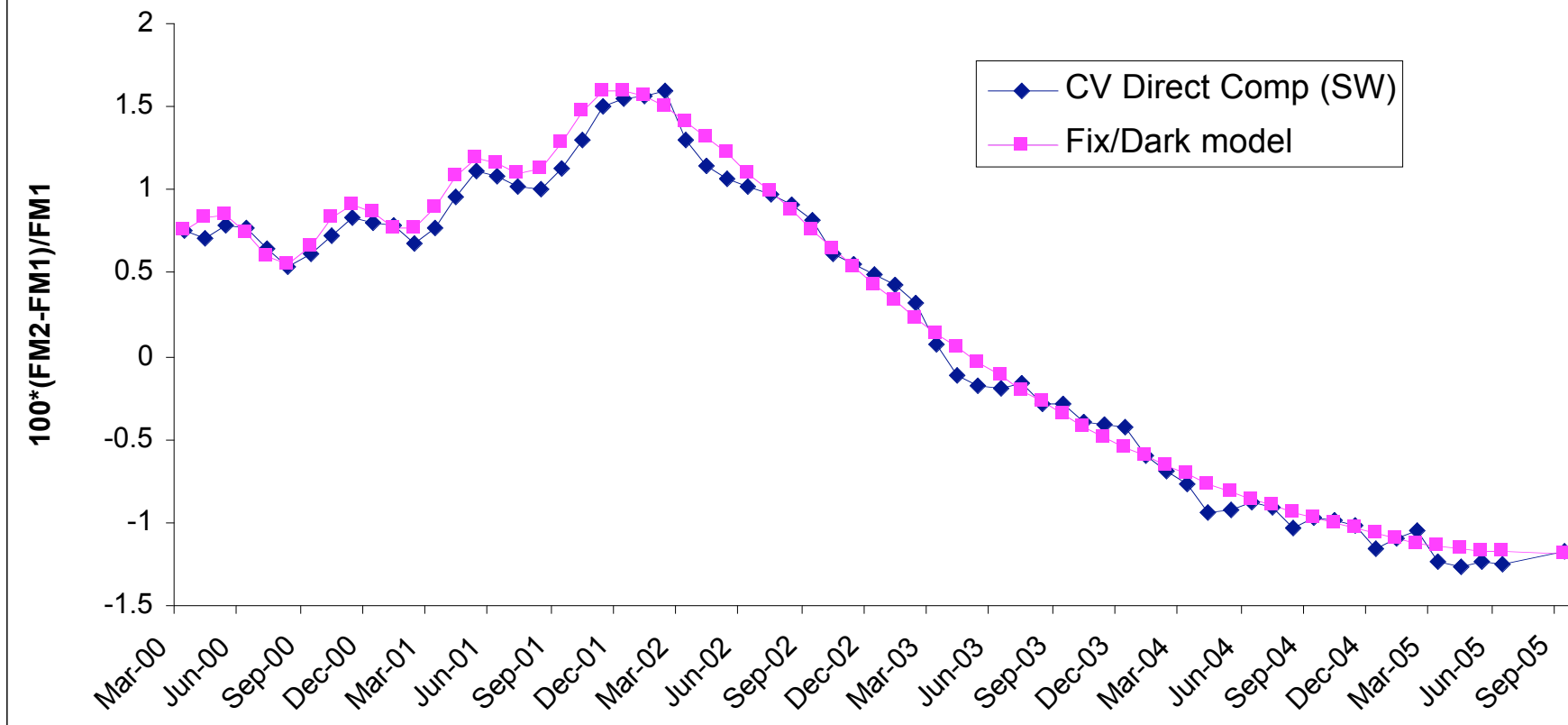
## Fix/Darkening model comparison with TERRA Allsky filtered direct compare



NASA Langley Research Center / Science Directorate



**Fix/Darkening model comparison with TERRA Clear Ocean filtered**  
**direct compare**

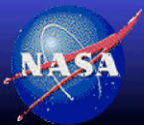
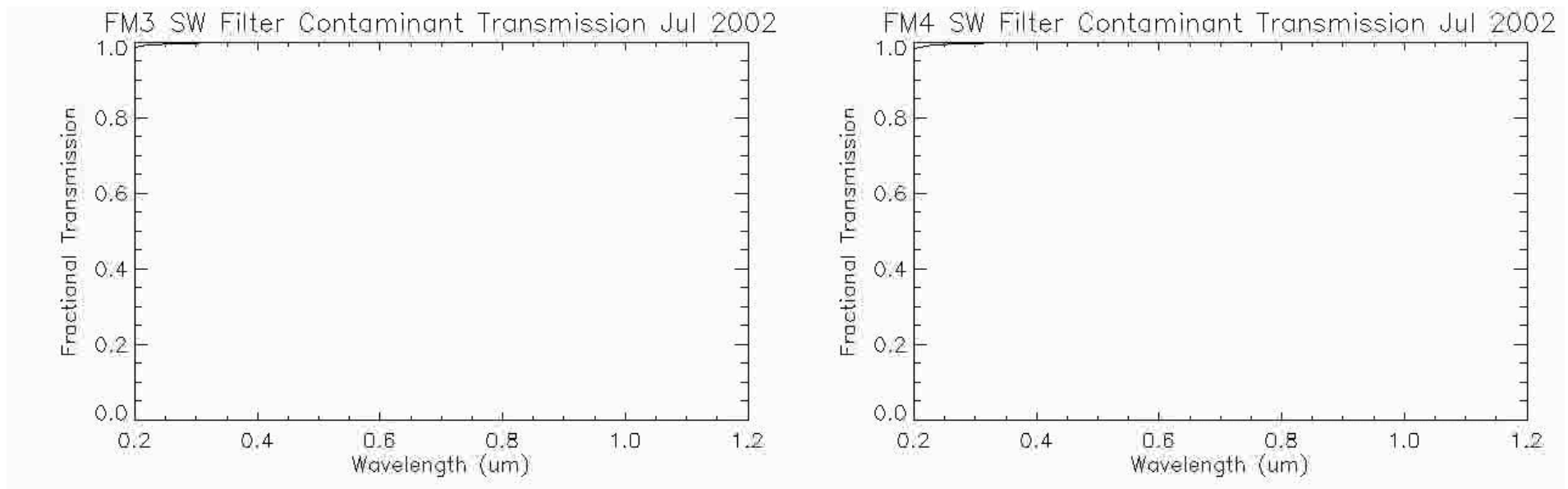


NASA Langley Research Center / Science Directorate



---

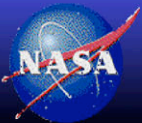
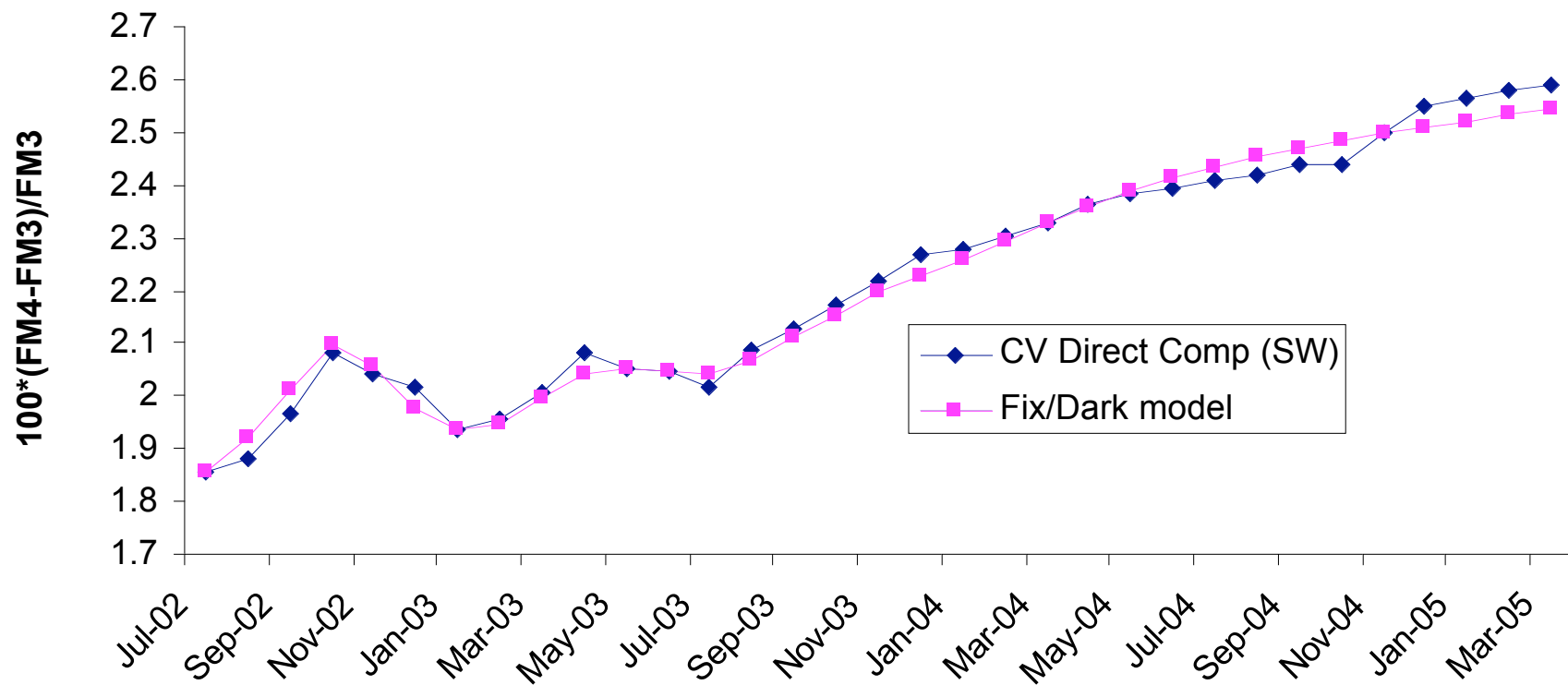
**The model can also be tuned to Aqua direct compare and internal calibration results:**



**NASA Langley Research Center / Science Directorate**



## Fix/Darkening model comparison with AQUA Allsky filtered direct compare



NASA Langley Research Center / Science Directorate



---

## Summary and Conclusions

- Rev 1 adjustments remove the majority of the spurious SW trends in Edition 2 data
- Special operations and modeling currently underway to characterize and compensate for RAPs and any Xtrack darkening in Edition 3 SW spectral response
- With SW channel model satisfactorily tuned, existing 3 channel inter-comparison method can be modified to derive any spectral darkening to total channel optics

